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BULLETIN

OF THE NEW YORK ACADEMY OF MEDICINE

Original Articles by

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Ford, R.V., and Moyer, J.H.: Rauwolfia Toxicity in the Treatment of Hypertension: Some Observations on Comparative Toxicity of Reserpine, a Single Alkaloid, and Alseroxylon, a Compound Containing Multiple Alkaloids, Postgrad. Med., January, 1958.

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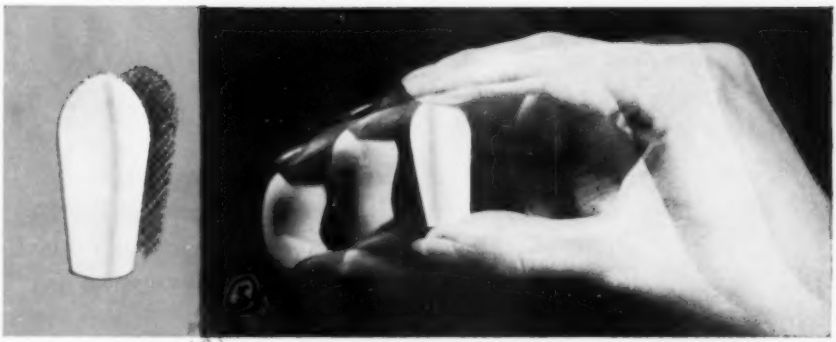

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Finnerty, F. A. Jr.: New York State J. Med. 57: 2957 (Sept. 15) 1957.

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Corrin, K. M.: Am. Pract. & Dig. Treatment 8: 721 (May) 1957.

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1. Rein, C. R., Fleischmajer, R., and Rosenthal, A. L.: J. A. M. A. *165*:1821, (Dec 7) 1957.
2. Shelley, W. B., and Pillsbury, D. M.: Personal Communication.
3. Sherwood, A., and Cooke, R. A.: Personal Communication.
4. Freyberg, R. H., Berntsen, C. A., and Hellman, L.: Paper presented at International Congress on Rheumatic Diseases, Toronto, June 25, 1957.
5. Hartung, E. F.: Personal Communication.
6. Schwartz, E.: Personal Communication.
7. Sherwood, A., and Cooke, R. A.: J. Allergy 28:97, 1957.
8. Hellman, L., Zumoff, B., Kretshmer, N., and Kramer, B.: Paper presented at Nephrosis Conference, Bethesda, Md., Oct. 26, 1957.
9. Ibid.: Personal Communication.
10. Barach, A. L.: Personal Communication.
11. Segal, M. S.: Personal Communication.
12. Cooke, R. A.: Personal Communication.
13. Dubois, E. L.: Personal Communication.

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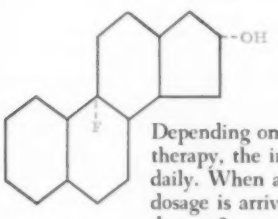

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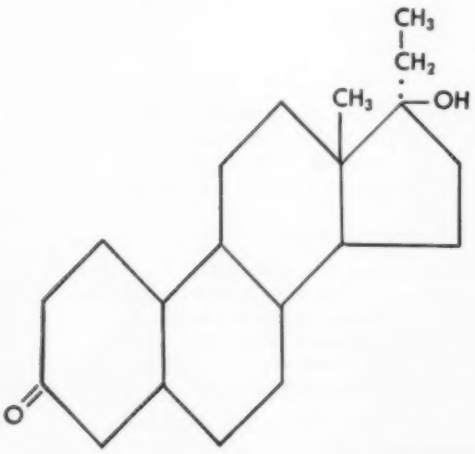

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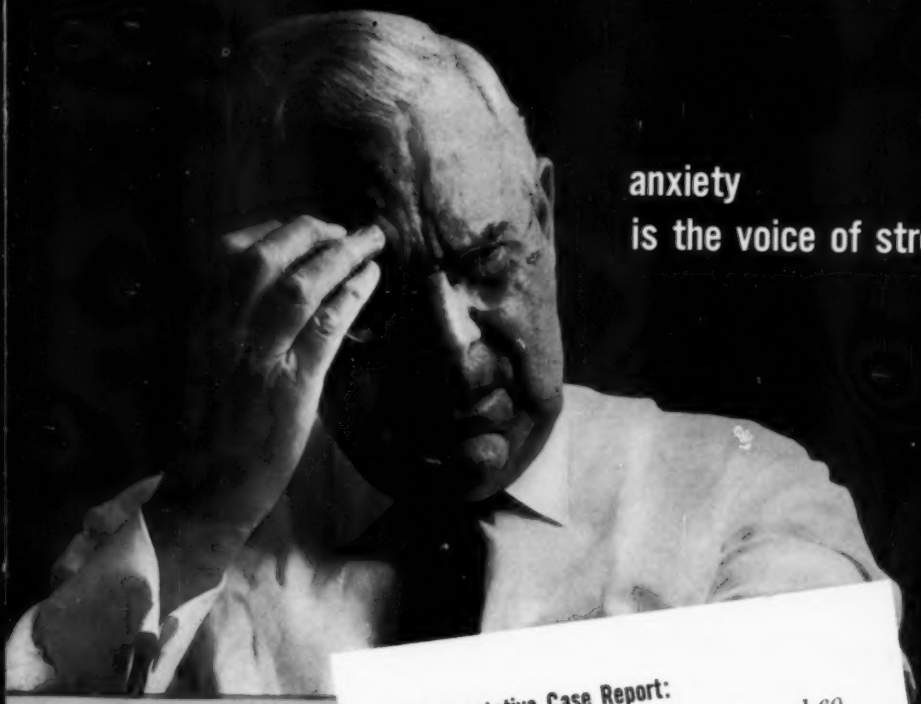

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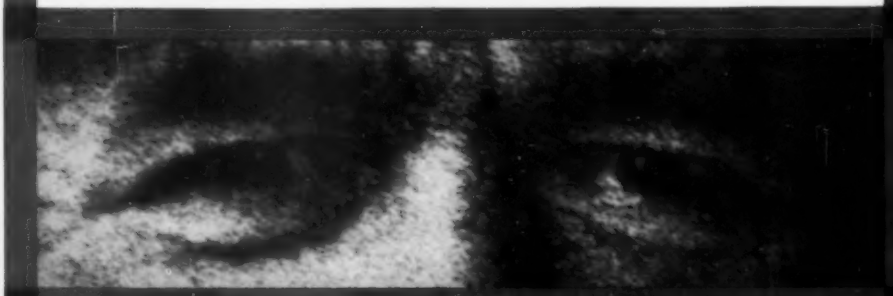

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Source—Hyman, M.: Some Aspects of Psychiatry in General Practice, GP *16*:83 (Oct.) 1957.

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*Bauer, H. G.; Seegers, W.; Krawzoff, M., and McGavack, T. H.: A Clinical Evaluation of Ectylurea (NOSTYN®), in press.

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1. Harris, R., and Del Giacco, R. R.: Am. Heart J. 52:300 (Aug.) 1956. 2. Weiss, A., and Steigmann, F.: Am. J. M. Sc. 227:188 (Feb.) 1954. 3. Dimitroff, S. P.; Griffith, G. C.; Thorner, M. C., and Walker, J.: Ann. Int. Med. 39:1180 (Dec.) 1953. 4. Hejtmancik, M. R., and Herrmann, G. R.: Texas J. M. 51:238 (May) 1955. 5. Batterman, R. C.; DeGraff, A. C., and Rose, O. A.: Circulation 6:201 (Feb.) 1952.

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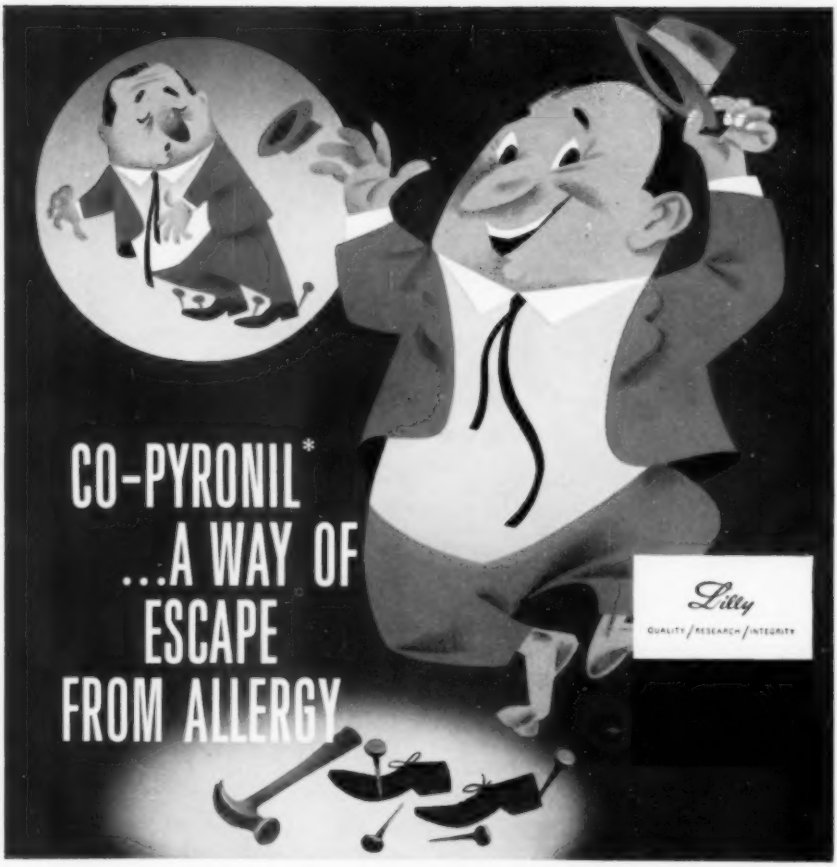

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AUTHORS ALONE ARE RESPONSIBLE FOR OPINIONS EXPRESSED IN THEIR CONTRIBUTIONS

ROBERT L. CRAIG, *Editor*

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BULLETIN OF
THE NEW YORK ACADEMY
OF MEDICINE

VOL. 34, NO. 7 JULY 1958

ANXIETY AND TENSION*

The Thirty-Third Hermann M. Biggs Memorial Lecture

RALPH W. GERARD

Professor of Neurophysiology in Psychiatry and Physiology,
Mental Health Research Institute, University of Michigan,
Ann Arbor, Michigan

I AM particularly honored to speak as the Hermann M. Biggs Lecturer. Partly as a result of the work of such a towering figure as Dr. Biggs, the problems of epidemiology are no longer so insistent at the level of microbes, perhaps not even at the level of viruses. It is other kinds of germs that seem to be disturbing us, the germs of fear and anxiety and the infections of hate and jealousy. It is indeed a period of dis-ease in the mental realm.

One of my colleagues, Dr. Rodin, who has been using a stimulant drug, megamid, as a diagnostic device to bring out abnormal brain wave activity when epileptoid conditions are suspected, found that the threshold for producing electric spikes was by no means constant. He wondered if certain personality characteristics were associated with a low threshold and tested a group of volunteer students. Practically a third

* Presented at the Stated Meeting of The New York Academy of Medicine, February 6, 1958. Program arranged by the Committee on Public Health.

of these normal, healthy young men showed what were regarded as pathological responses. Inquiring into their histories, including the psychological aspects, he found that these men had shown some kind of psychiatric abnormality in the past. Next he obtained the same information from a comparable group, selected at random from the student list, and found the same proportion of abnormal ones.

On these criteria, something like a third of our present healthy population is suspect, at some level, of neurosis—if not psychosis. So, perhaps it is not too surprising to find that a wave of interest in psychoactive or phrenotropic drugs has swept the world, and particularly this country. The tranquilizers, one large group of them, are particularly known; and now the energizers, which supposedly do just the reverse of tranquilizing, are gaining much attention. Three of the ten most frequently prescribed drugs in this country are tranquilizers and in 1956, the latest figures I have, 34,000,000, prescriptions (not tablets) were written for them. That number of prescriptions is equivalent to about 20 per cent of the population. If children are excluded, the guess of a third with psychiatric problems isn't so far off.

We are commonly told that this is an age of great tension and stress, and we blame the situation upon the fact that the world has shrunken. We are closer together, we are more in communication, the pace is increasing; and therefore we feel very insecure. The facts of a smaller world and bigger bombs are, of course, quite correct. I find myself, however, not too impressed by this. After all, we can go to bed at night and be reasonably certain that our house will not be broken into, nor we hauled out of it. Most of the time in most of the country we can walk the streets without fear of molestation. Our wealth and possessions are ordinarily reasonably protected. If one does lose all his money, he is still likely to have his basic needs cared for by welfare mechanisms. In fact, I rather suspect that we are not in a period of undue insecurity, but we are in a security state. To be sure, the bombs are bigger, more money is involved, and the issues facing men are more far flung; but most people take seriously only those things with which they become personally involved. A person can be killed just as dead with a knife as with a hydrogen bomb, and can worry just as much about losing one hundred dollars as one million. If we are indeed more troubled today, I think that our concern is not because of greater insecurity *per se* but, more likely, because of greater awareness. Stress, worry and anxiety—and in

a moment I shall be more precise about what I mean by these words—involve a cooperation on the part of the worrier. Unless situations have a real meaning to a person, they are not disturbing.

In a marvelous tale by Kipling, a couple of camels are holding a discourse about military matters. One asks why the elephant is such a coward and can't be induced to go up to the firing line, while the donkey, no coward, will go up there. The other camel explains that it isn't a matter of cowardice at all. The donkey has no imagination, he doesn't know anything about the possible danger, to him the firing line is no different from any other place, so he just goes where led. But the elephant can see ahead, he has imagination and can understand the danger, so he is naturally anxious at any attempt to lead him to the front. "Well," asks the first camel, "How about man? He can see ahead, and he still goes to the firing line." "Ah," says the other, "that is what makes him a man. Even though he is anxious and understands the danger, he can still make himself face up to it." In that parable there is much of modern psychiatry.

I remember a first-year student undergoing a routine health service examination. The young man came down the line toward the examining doctor, normally enough, until a stethoscope was put to his chest; then he fell down in a dead faint. To check for a possible bad cardiovascular condition, he was asked to come back; but careful examination revealed no physical disturbance. Yet, when the doctor took out his stethoscope to listen over the precordium, the student again fainted. After various maneuvers, the student's heart was watched in front of a fluoroscope while the doctor brought objects from behind him into view. Nothing happened until a stethoscope was brought forward far enough to be clearly identified, when the heart would immediately stop—a conditioned reflex response. Clearly, something had happened to that boy in the past so that this instrument had a sinister meaning to him, consciously or unconsciously.

When in Australia a decade ago, I made some effort to look into tales of natives being "witched" to death. The aborigines are very primitive people, with tribal taboos often severe. When a member transgresses a major one, and is judged guilty, he is punished by ritual "pointing the bone". The medicine man uses a sliver of bone with human hair braided from one end, passing the braid between his legs and pointing the bone at the culprit. If additional potency is required, two or three men stand

behind the medicine man with the braid passed between their legs also. The transgressor need not be there, nothing else is done, he need only know that this punishment has been meted out to him. He then retires to his little niche and, in the course of two or three days, he dies. I tried hard to learn what actually happened to him but do not know the answer. I can only surmise that he dies of heart failure. The point is, of course, that this practice has a meaning, and only in terms of that meaning is a fatal stress and anxiety generated. Perhaps the cynical definition of education is not so wrong after all—an educated person is one who has learned to worry about things all over the world.

The less civilized human being, who did not live in an environment carefully tailored to his needs and with little immediate danger, was more like the ordinary wild animal; likely, between every step, or bite, or move, to freeze, flip his ears, roll his eyes, and sniff the breeze to see what danger is coming. Watch birds eating: they take one bite, look around to make sure nothing is threatening, take another grain, then look around again. Danger is imminent to them, yet they do not get the kinds of disturbances that man does. They do not have the apprehension, the projecting forward that characterizes man.

When situations are contrived which do subject animals to conditions similar to those affecting man, results are dramatic. A recent report from Russia described the behavior of a male chimpanzee under such conditions. He had been living happily with his wives until confined to a screened cage in the center of the compound, while a young male added to the group enjoyed the females and became lord of the territory. The deposed ruler, witnessing his successor's activities, was enraged, tore at the cage and screamed, and in three months died of a severe arteriosclerosis and hypertension. This experiment was repeated several times.

In the same category are results from a study in the United States. Two monkeys were kept "in parallel", so that what happened to one also happened to the other. When a lever was pressed, both monkeys got an identical shock and also got some food; if the lever was not pressed, neither got food or shock. When hunger became severe, one monkey would press the lever, both would be shocked and both ate. But only one monkey had access to the lever. At the end of some weeks one monkey died of perforated ulcer. Incidentally, the experimenters maintained that they could distinguish psychiatrists from physiologists by the guess made as to which monkey died, the one in active control or the

passive "victim". Actually the monkey that had to make the decision got the ulcers.

Let me move on to the question of tension, anxiety, emotion, and stress. These terms are freely intermingled and lack precise operational definitions, although they certainly can be identified under different conditions. To mention the wider gamut of emotions and stress reactions, there are the basic ones of anger and fight, of fear and flight, of hunger and food, and of sex. A more complicated class includes anxiety and apprehension, and guilt and shame, which are not so primitive. Anxiety is different from fear. Fear is a clear response to an immediate threat, a dangerous situation; anxiety, psychiatrists interpret as anger not expressed outward, against the source of the annoyance, but turned inward—as are guilt and shame. This internalization is a cultural matter; it is based on human interactions and socially-induced inhibitions. Indeed, one could make the nice point, I think, that, in Dr. Bigg's day and still to some extent in ours, the main biological issue of disease was between the multicellular organism, man, and the unicellular organism, the microbe, while today the issue is between the multi-individual society and the uni-individual man. In the tension-anxiety situation, display or discharge of the primitive reaction is often culturally forbidden.

Some workers argue that the individual reactions are not physiologically distinct. I do not think this is completely correct, for experimental psychologists have devised situations in which all subjects gave physiological responses clearly associated with anger or with anxiety. But in most real life situations, the kind of response to a given insult of fortune is not uniform for everyone but depends to a considerable extent on the responding individual; on his constitution, his temperament, and his upbringing. Recent studies in Boston indicate that in a given frustration situation, some subjects reacted with anger, others with anxiety. The subjects, all students, who had been brought up primarily by an authoritarian father, and in a less stratified social environment, directed their anger outward in overtly hostile responses; whereas those who had a dominating mother, often no father present, directed their anger inward and suffered anxiety.

Thus far I have touched upon the pattern of stresses or tensions in general, now let us consider anxiety more particularly. To me, anxiety is largely connected with frustrated drives, especially under

conditions in which the response is turned in. Anxiety is shown in dreams, which involve a continuous activity of the brain due to unresolved or unassimilated recent experience. A New York psychiatrist tells of a linguist patient who, while visiting a distant city, wanted to telephone a girl friend. He did not have her telephone number with him, knew it was unlisted, and was desperately frustrated because he could not recall it. All night he dreamt of red objects—red sunsets, red dresses, red pictures—and on awaking immediately said, "Oh, the number is 1854". He was used to identifying letters by their position in the alphabet, from 1 to 26, and R, E, D gives 1854. This is an example of dream work and of unfinished business. Anxiety is particularly associated with unfinished business; with events to come even more than events from the past. Anxiety is common when an important decision is to be made; when waiting for a particularly important message, as a 'phone call or letter. Time then becomes interminable, the stress gets worse and worse as delay extends, and a predisposed person can go into a true anxiety panic. Really nothing whatever is happening, there is just maintained uncertainty.

In an intensive study of stress, conducted at Harvard, normal people were placed under severe stress. It was postulated that maximum athletic effort, a terrific physical output, would impose great stress, so tests were made on the crew before, during, and after the Harvard-Yale race. The oarsmen, who ended up completely exhausted, did indeed show a great fall in eosinophils, a type of blood cell, which is a measure of stress; but the coach, who had been "sweating it out" on the side lines, had an eosinophil count much lower than any of the oarsmen. In the coach no physical stress had been involved, but there was plenty of anxiety and apprehension waiting for the outcome.

A person has the same kind of anxiety when the decision is not an external but an internal one, when faced with an important choice. While deciding whether to do this or that, with any important unsolved problem, a severe anxiety state can build up. With some unfinished business, an individual is not at ease, not relaxed, and such an unsettled state can last for years. Great creative scientists and artists have reported such unsolved problems gnawing at them for prolonged periods until the solution finally clicked and brought great relief. The same phenomenon occurs in the learning child. There is tension while some new experience or new concept remains unassimilated; then, with

comprehension, come real joy and excitement and release as the child says, "Oh that's what it is! Now I understand!" Still another basis for anxiety is what I have called the "unbalanced emotional equation". If one person has wronged another the latter either forgets it or builds up a sense of injury and tension and the resolve "to get even some day". Finally, in one way or another, this emotional balance is squared; the accounts are settled and the tension is discharged—even though the original damage to the settler is not thereby resolved. In its primitive form this reaction is seen in the child who, having stumbled over a rock, gives it a vigorous kick. This action somehow squares the emotional account, even though adding a new insult.

So much for description, let us now turn to the physiological aspects of anxiety. Aside from the great central nervous system, there are clumps of nerve cells, ganglia, and strands of finer nerves which go to practically all the viscera. They are called the autonomic nervous system, because they more or less operate on their own; and there are two subsets, the straight or orthosympathetic division, and the opposed or parasympathetic division. Whatever one set of nerves does to a particular viscus or organ, the other set does the opposite. The orthosympathetic nerves produce speeding of the heart, rise of blood pressure, erection of hair, flushing of the skin, dilation of the pupils, liberation of sugar into the blood, and much else; and the parasympathetic nerves do just the opposite. The latter system increases gut action, stimulates many secretions, etc.; the orthosympathetic tends to stop those actions. A particularly interesting peripheral connection of these nerves is to the adrenal—the small endocrine, hormone secreting, gland above the kidney, composed of an inner core or medulla and an outer shell or cortex. These parts have different functions, produce different hormones, and are under different control. The adrenal medulla, which now concerns us, is under the control of orthosympathetic nerves, which stimulate it to release its hormones. It was formerly thought that the medulla had only one hormone, adrenalin or epinephrine; it is now known that there are at least two, epinephrine and nor-epinephrine, closely related compounds but with distinctive actions.

The central nervous system thus has a direct endocrine connection via the autonomic nerves; it also has an indirect connection via the so-called master gland of the body, the pituitary or hypophysis. The lower part of the brain, the hypothalamus, in particular, has lines of com-

munication with the endocrine system. The pituitary lies just below it and there are both nerve and vascular connections between hypothalamus and pituitary; so the nervous system and the endocrine system can interchange messages and controls. The pituitary, in turn, by virtue of its hormones, is able to activate most of the other glands in the body. One of its hormones is ACTH, adrenocorticotropic hormone, which stimulates, not the adrenal medulla, but the adrenal cortex. From this come cortisone and a number of other steroid (corticoid) hormones, related to the sex hormones. (Some wit once remarked that ACTH really meant, "After Cortisone Try Hadacol.") All the hormones are therefore under control, in one way or another, of the central nervous system, and particularly of this basal region—the lower part of the front end of the brain stem, but below the new great cerebrum that appeared more recently in evolution.

It has been clearly shown in recent years that different parts of the hypothalamus are particularly related to different parts of this neurohormonal system. It is possible, for example, to implant electrodes in the brain. When the anterior part of the hypothalamus is stimulated, feelings of fear and anxiety are generated and epinephrine is liberated from the adrenal medulla, indeed from the brain itself. This latter response is another recent finding; there are structures in this part of the brain which have a rich supply of the adrenal hormones. Stimulation a little further back in the hypothalamic region produces in the conscious animal behavior that looks like rage; and liberation of nor-epinephrine, not epinephrine, can be demonstrated.

Further, there is evidence that it is possible to activate the epinephrine and the nor-epinephrine systems separately. The former is associated with experiences of anxiety; the latter, with experiences of anger and rage. Epinephrine, when injected even in amounts that cause no measurable change in pulse rate or blood pressure, will produce an intense feeling of anxiety and ill-at-easeness. The hormone actually increases considerably the oxygen consumption of the brain; and it was found a few years ago in our laboratory that stimulation of a small region in the hypothalamus will lead also to considerable increase in cerebral metabolism. In contrast to epinephrine, injection of a small amount of nor-epinephrine produces considerable rise in blood pressure, and eventually perhaps some feeling of anger. There is, then, a physiological basis for separating the responses of the adrenal system into

an anxiety-fear type and an aggression-rage type. The separate responses are mediated through somewhat different brain regions and through identifiably different hormones liberated through different mechanisms and systems.

Between orthosympathetic activation and parasympathetic activation, there is also clearly a difference. This development is a further elaboration of the fundamental contribution by Walter Cannon, the distinguished physiologist, who accounted for responses of the whole autonomic system and of the adrenal medulla in terms of meeting an emergency to the organism. In real danger, fright or anger appeared, pain was probable, and activation of the autonomic nervous system occurred. These responses, Cannon said, prepared an animal for fight or flight rather effectively. But the response is not a mass action of the whole autonomic system; rather, emotional states can be subdivided Not only does ordinary psychological awareness recognize that anger, anxiety, and fear are different in ourselves; but also physiological evidence shows that the body changes paralleling these emotional responses differ from one person to another. The particular way in which a given person responds will depend to a certain extent on the situation, of course; but also it will depend to some extent on the individual himself, with his own hereditary endowment and past experience. There is certainly a specificity in one's emotional personality. Perhaps it may be exemplified by the storied characterization of four kinds of administrators: when something goes wrong, the adenoidal one yells, the thyroidal one rushes around, the ulceroidal one worries, and the hemorroidal one just sits on the situation and waits for it to clear up.

It seems that now a clear and meaningful story can be told about the course of physiological events, starting from the brain. Given the fact that appropriate brain regions have become active, paths can be traced through the peripheral autonomic nerves, through the chain of endocrine glands, and through their interactions with each other, so that the ensuing organic effects are understandable. Additional evidence comes from the whole field of psychosomatics, with the various sustained disturbances in organs that will result if states of excessive stimulation emanating from the nervous system continue for any length of time. These disorders include peptic ulcers, hypertension, asthma, ulcerative colitis, neurodermatitis, etc., in all of which, whatever else, organic components are certainly present.

There are also other somatic changes linked quite specifically with anxiety. I have emphasized activity of the adrenal medulla, but the adrenal cortex can also be involved. In maintained anxiety of any intensity, there is seen in the urine an increased output of the metabolic end-products of hormones released from the adrenal cortex as well as from the adrenal medulla. The anti-diuretic hormone of the pituitary gland can also be detected in the urine under conditions of anxiety. Another bodily reaction affected by anxiety is the combination of ingested benzoic acid, a toxic substance not normally present in the body, with glycine, an amino acid component of many proteins, to form nontoxic hippuric acid. In anxiety, the amount of hippuric acid excreted in the urine in response to administered benzoic acid is decreased.

Recently a biochemical test for schizophrenia was announced. When a particular reagent was added to blood, a distinctive color would develop, and the sicker the patient, the deeper was said to be the color. Blood from normal persons did not produce the color. Unfortunately, this reaction does not quite work out as a test for schizophrenia. But the blood does indeed contain a substance, ceruloplasmin, which may be present in increased amount under certain conditions, particularly in acute schizophrenia; and this increase is responsible for the color test. A former colleague now has evidence that the increased level of ceruloplasmin in blood is not an index of any specific disease, but that it is a fairly good measure of the level of anxiety. In acute schizophrenics the anxiety level is likely to be high. The increased ceruloplasmin is probably released by the liver, under conditions of anxiety; and formation of hippuric acid also involves the liver. Here is an instance of related activity of brain, autonomic nerves, endocrine glands, and the main organ of body metabolism.

At this point let me turn to anxiety and the nervous system. How is anxiety related to the nervous system itself; what are the central neural or conscious concomitants to the somatic effects of anxiety? Before answering, I must make a brief detour into the meaning of consciousness itself.

Most biologists have a rather firm faith that whatever has appeared, survived, and developed in the course of evolution, has done so because of some utility to the organism. Useful things have survival value; indeed, in the great majority of cases, what the value is can clearly be seen. When one cell stayed with another, a multicellular organism re-

sulted and this had real value. When a water-resistant skin was put over that organism, when locomotion developed, when warm-bloodedness appeared, when eggs, uterus, and care of the young came into being—each of these was clearly helpful for the survival of the race or species. Consciousness has also undergone evolution. If the most primitive animals with nervous systems had any awareness, it was certainly something so different from what we know that they would not easily be equated. The whole spinal cord is just insensitive. When separated from the upper part of the organism, it performs its functions about as before; the most elaborate, coordinated, adaptive reflexes are still operating without any sign of an awareness.

In the more developed organisms, stimulation of the region at the top of the primitive nervous system, the midbrain, leads to a generalized awareness. One part of this region, the reticular formation, is particularly related to consciousness in man and other higher animals. When it is depressed, consciousness is wiped out; when it is activated, consciousness becomes more intense. Associated with these changes in consciousness are decreased or increased electrical activity of the cerebrum; in fact the reticular formation, able to activate the higher brain, has been called an alerting system. This ancient brain thus serves a primitive simple awareness and also influences the newer upper part of the brain. Later, evolution superimposed upon this region a group of structures at a higher level; a new top of the brain superseded the old top of the brain. As organisms evolved further and became larger, more elaborate mechanisms were needed. These new structures, including the hypothalamus and the limbic system, are associated with the expression, and probably with the actual experiencing, of affect or emotion. Before their development, organisms probably had just raw, undifferentiated awareness; with them there could be affect, and pain seems to have come before pleasure.

Some dramatic recent work justifies more positive statements, which physiologists were previously hesitant to make. For example, an experimental animal may be trained to press a lever and give itself a shock. If the animal presses once, emits a squeal, and then avoids that lever, it is fair to conclude that the animal did not like what happened. Conversely, having given itself a shock, if the animal continues to shock itself five times a second for two days, until absolutely exhausted, the obvious deduction is that the animal liked something

about the self-induced experience. These negative and positive systems have been explored throughout the brain of animals from rat to ape, and, to the extent that it has been legitimate to extend such studies to man, subjective reports have agreed with the expectations from the animal experiments.

Thus, primitive awareness came first; then affect or emotion, pain and pleasure, followed. Only later, with the development of the cerebral cortex—which appeared in the mammals, got large in the primates, and became really over-stuffed in man—, did intelligence, foresight, and projection appear. This is the course of development of consciousness. From its inception it has become progressively more elaborated; presumably it has some general significance to the organism and its welfare. I suggest that the same emergency reaction, already considered in its peripheral manifestations, operates in the brain itself to evoke consciousness and the anxiety associated with it.

The individual nerve cell, the neurone, is about the same size as most other cells, but it differs in that it has long processes. One pole picks up stimuli and excitation, either on the main body of the cell or on relatively short dendrites; the other, a long, thin fibrous extension called the axon, carries the message on. When the cell is stimulated at one end, a message is set off which runs down the fiber. This, in turn, usually connects with another nerve cell; the connection is called a synapse. If messages are to go through a typical reflex arc, for example, they must cross several synapses, one neurone progressively activating a second, this a third, etc.

In the great majority of cases, when a single nerve message comes to a synapse, it does not succeed in exciting the neurone beyond. It dies out. Nonetheless, if several messages in the same fiber, or messages in several fibers near each other, focus upon the postsynaptic neurone within a short time and a narrow space, excitation builds up; they add or summate. Hence, whereas one impulse will not cause the postsynaptic neurone to discharge, repeated impulses will summate and discharge it. Summation is, therefore, the first phenomenon in the transmission of an impulse from neurone to neurone. Messages come in but may not get through a particular path; yet, if they continue to come in for a while, they do get through. Additional neurones are engaged and become part of the active system. This is one step.

Suppose now that more and more messages reach this second neurone.

Again, summation can occur and after a while a third neurone will become active. There results a progressive spread of messages to more and more active neurones. This is the phenomenon of irradiation; and a continued inflow of nerve messages can lead to widespread activation in the nervous system. This is the second step and leads to a third one. Most pathways do not simply start with a neurone at one end and continue through a simple chain to the other; only in the simplest reflex does the message follow such a route. In most cases, some neurones connect back with others to produce loops, and a message may get into one, reach the second, third, etc., and find itself back where it started and ready to go again around the same path. Actually, the loops may be complicated, intricate, three-dimensional chains or assemblies of neurones and impulses can reverberate for some time.

First with summation, then with irradiation, and then with reverberation in a looped system, a continued stimulus may set up impulses that keep going over the same pathway, like a merry-go-round, for very considerable periods. Finally, if they go around often enough, they leave some kind of irreversible trace or change in the nervous system, an enduring memory. The organism has learned from its experience. We were able to show this decisively by experiments in which electric shocks were applied to hamsters so as to stun their brains. If they ran a maze and received a shock an hour later, they remembered what they had learned; but if they received the shock a few minutes later they retained nothing. Time had to elapse after the actual experience, during which fixation went on in the nervous system.

Most of the problems presented by the environment in which the organism has to exist and maintain itself are repetitive and familiar, and the solutions are similarly routine. Most of the events in the nervous system, therefore, are not new; in fact, most solutions have been built in during evolution of the race. The reflex paths are operative in the new-born nervous system; and the responses handle disturbing situations by pulling away from a pain-inducing object, by winking the eye, and myriad other inborn automatic reflexes. Furthermore, something learned can also become reflex, automatic, and unconscious. As long as the available solution, achieved by racial or individual habit, resolves the problem—eliminates the stimulus—that response is sufficient and, in the overwhelming number of instances, the action goes on quite unconsciously. You have all experienced this; perhaps, as I, you have

started to change a shirt for dinner and, first thing you know, found yourself undressed and in bed. When one's mind is on something else when initiating a chain of habitual acts, the whole sequence may be executed without the least awareness of it.

But when the routine behavior does not suffice to eliminate the disturbance, answer the question, resolve the issue; when there is unfinished business, then of course, the stimulus continues. Impulses still pour into the nervous system, since the automatic response was ineffective, and a new kind of behavior, creative or innovative behavior, is called for. New paths through the nervous system are required, and the mechanisms already considered produce them. With the stimulus continuing, extra nerve impulses pour into the brain, produce summation at the regular synapses and so are able to irradiate to new neurones, and then set up reverberation activity in new loops of the total neurone network. (Similarly, volume spread may occur and a hypersynchronization develop.) With sufficiently continued reverberation (or synchrony) some permanent trace is left behind, and experience is fixed. This is involved in memory—probably also in repression and even in perception. When these new neurone fixations or behavioral habits are inappropriate, a neurosis is the result.

When the disturbance is sufficiently great, additional emergency mechanisms come into play. Irradiation seems to spread from cerebrum to the neuraxis or from the new brain into the old brain, the hypothalamus and reticular formation, and so sets off both the reticular alerting system and the adrenal hormones. From the reticular formation, generalized nerve impulses barrage the cerebrum and so re-enforce the messages coming from the outside world. Messages from the hypothalamus lead to the release of epinephrine, which lowers the thresholds of cerebral neurones. The combination of more stimuli arriving, with fewer stimuli required to excite, necessarily results in a more rapid and extensive irradiation of excitation in the brain.

As more neurones become engaged, anxiety appears. With mild anxiety, and a moderate increase in active neurones, there is, as one might expect, a general improvement in performance. With medium anxiety, and a considerable fraction of the available neurones engaged, performance becomes more rigid, with less exploration of alternate behaviors. Again, this is what would be expected from the decreased reserve of uncommitted neurones. Finally, with severe anxiety most of

the neurone reserve is committed to existing assemblies and to carrying unproductive reverberating messages, and performance deteriorates and even collapses. With no cell reserves remaining—which may be a physiological translation of "loss of psychic energy"—innovative behavior is no longer possible and actions again become stereotyped but are now unadaptive or neurotic.

Ordinarily the innovative behavior, accompanied by only tolerable anxiety, does solve the problem or finish the business, and a type of closure is attained. The surging patterns of activity cease in the brain and, unless the episode was sufficiently intense and prolonged to produce a permanent fixation, the whole is wiped out. A good example is the way one holds a telephone number in memory after finding it in the book but forgets it immediately after the dialing is completed.

But when the stimulation has been excessive, or the neurone thresholds have been too low, then some of the activity set up may endure long after the disturbance has disappeared. Then an abnormal level of activity may remain as a chronic state and produce mental illness. This is probably involved in the neuroses, as in a chronic anxiety state, due to excessive stimulation. And if some present views regarding schizophrenia gain support, such as the presence of excessive amounts of epinephrine and its oxidation products in this illness, then the overactive states of this disease might be interpreted in terms of the lowered neurone thresholds producing the chronic disturbance.

We are already at or even beyond the limits of safe interpretation from biological conditions to psychological performance, and it is time to close. You might tend to conclude, from the way in which this story has been developed, that the ideal state is one of minimal disturbance and adjustment; but this would be a false conclusion. A balance of stimulation and the resolution of stimulation is needed, both during development and in maturity. Too little environmental disturbance leads, not to Nirvana, but rather to a vegetable-like existence. (Brief periods of minimal sensory stimulation may actually lead to psychotic-like experiences.) Too much harassment and stress from the outside world, conversely, lead to an unhappy and ineffectual life. Man functions best when a moderate number of neurones is active and when there remains a reasonable number in reserve; the extremes of "not a brain cell working", on the one side, and of all brain cells engaged in useless reverberating activity, on the other, are not desirable states.

Fortunately, man has additional built-in mechanisms that help him seek the proper level of brain activity. After a bout of activity, fatigue and sleep set in. Indeed, the function of sleep may be just to interfere with ongoing reverberations that otherwise would become too fixed and permanent. With advancing age, and the reduced reserve of usable neurones, there is a general slowing and the attendant decrease in the environmental demands. Man has found in nature drugs to depress or to stimulate his nervous system, and he early learned to improve upon what was at hand. Every group of civilized man has used the depressants available to it—opium, hashish, marijuana, alcohol—; but even more widely and enthusiastically has it used the stimulants—coffee, tea, mate, cocoa.

Man seeks to find and meet the challenge of a dynamic existence. As the fires cool, as passion is spent, he speaks with Swinburne:

> From too much love of living,
> From hope and fear set free,
> We thank with brief thanksgiving
> Whatever Gods may be
> That no life lives forever;
> That dead men rise up never;
> That even the weariest river
> Winds somewhere safe to sea.
>
> (From "The Garden of Proserpine")

But while in the full surge of maturity man presses against the frontier of life and speaks with Untermeyer:

> From compromise and things half-done,
> Keep me, with stern and stubborn pride;
> And when, at last, the fight is won,
> God, keep me still unsatisfied.
>
> (From "Prayer")

SOME CURRENT VIEWS ON THE BIOCHEMISTRY AND PHYSIOLOGY OF MYOCARDIAL CONTRACTION*

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I. Introductory Comments

The heart is a compact muscle mass with the same fundamental function of contraction and shortening as that of any skeletal muscle, such as the gastrocnemius or biceps. However, the heart's contraction serves the unique and highly specialized function of repeatedly propelling adequate quantities of blood into the pulmonary and body circulations. Therefore efficient, organized, rhythmic myocardial contraction can certainly be viewed as far more vital to the continued well-being of the entire organism than is the contraction of any given skeletal muscle, or any large group of body muscles. Further, any serious derangement or abnormal alteration in cardiac contraction may jeopardize or greatly shorten the life of the individual. Still further, the physician has within his command numerous sensitive means for assessing cardiac function, and in an increasing number of circumstances, he now has available certain helpful physical or chemical methods for reversing failing heart function or for reducing the severity of cardiac dysfunction. Therefore, it behooves us as physicians to review frequently our current understanding of the basic mechanisms resulting in the contraction of cardiac muscle and to apply that knowledge where possible to better preservation and care of the heart of the patient served in medical practice. The ensuing discussion attempts to present a limited review of certain basic aspects of the physiology and biochemistry of heart muscle and to expand on selected areas of investigation with which the writer has dealt in the laboratory.

A portion of this discussion will be devoted to an experimental

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inquiry into the chemical compounds whose degradation yields the energy eventually captured by myocardial fibers for conversion into the mechanical energy which ultimately produces the fiber shortening characteristic of muscle contraction. A second aspect of experimental cardiac physiology which has concerned us recently is the production of acute failure in the heart-lung preparation by depression of blood pH and the reversal of that failure by several cardioactive agents. Some findings from this study and their possible functional meaning will also receive comment.

II. Comparison of Skeletal and Cardiac Muscle

The heart is generally considered to be a syncytial muscular pump and thus differs greatly in practical function from body muscle, which serves as a contractile lever. A question long asked by physiologists[1] concerns a mechanistic comparison of these two functionally different types of muscle: Is the sequence of contractile events identical in skeletal and cardiac muscle? Or is the biochemistry of cardiac contraction, like its working function, uniquely different in quality or quantity from skeletal muscle, a difference which permits the heart to perform repetitively 100,000 times per day its unique task of propelling blood into the body circulation?

Accumulated experimental evidence seems to indicate that both heart and body muscle derive the energy for their contractile tasks in essentially the same manner from very similar types of fuels. If differences between the biochemistry of the two types of muscle exist, they appear thus far to be differences in detail or in quantity rather than in broad areas of basic mechanism.

III. The Chain of Events in Myocardial Contraction

Biochemically, the task of the heart is essentially that of any of the organs of the body, including skeletal muscle. The heart, like other organs, must 1) receive from the capillary circulation oxygen and energy-containing fuels, 2) degrade these fuels by oxidation to release the available energy, 3) capture and store that energy in a manner making its utilization efficient, and 4) convert the stored or captured energy into useful work.

Suppose for illustrative purposes (Figure 1) we assume glucose to be a primary carbon-containing fuel for utilization by the myocardium.

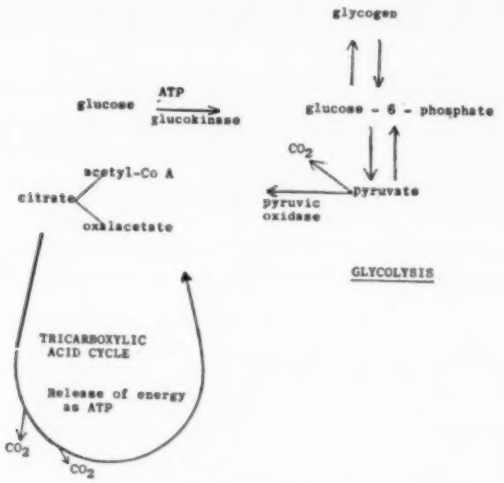

Figure 1.—Schematic outline of glycolytic and oxidative reactions in cell intermediary metabolism of glucose.

This role of glucose will be documented in later paragraphs. Once delivered to myocardial cells from the coronary circulation, this 6-carbon sugar enters the biochemical factory by phosphorylation to glucose-6-phosphate under the enzymatic influence of glucokinase (hexokinase) and the energy-laden nucleotide, adenosine triphosphate (ATP). Each molecule of glucose-6-phosphate so formed may be incorporated into glycogen or alternatively may be swept into the main stream of carbohydrate metabolism, the glycolytic series of reactions, ultimately to form two identical molecules of the 3-carbon compound, pyruvic acid. In the heart, an essentially aerobic organ plentifully endowed with respiratory enzymes[2], pyruvate is quickly transformed by pyruvic oxidase and certain co-factors to acetyl-coenzyme A (acetyl CoA), long sought as the active link between fatty acid and carbohydrate metabolism. A condensing enzyme attaches the two carbons of acetyl CoA to the four carbons of oxalacetate and sends the product, citric acid, around the oxidative wheel of the tricarboxylic acid cycle (or Krebs cycle)[3]. The net result of this cyclic process is the release by decarboxylation of two molecules of carbon dioxide and the regeneration of oxalacetate, which is then available to mesh with a new molecule of acetyl CoA for another trip around the

Glycolysis

1 glucose ⟶ 2 pyruvate + energy (92,000 cal.)

Oxidation and oxidative phosphorylation

$2 \text{ pyruvate} + 5O_2 \longrightarrow 6CO_2 + 4H_2O + 30 \sim P$ (345,000 cal.)

Efficiency

$$\frac{92{,}000 \text{ cal.} + 345{,}000 \text{ cal.}}{686{,}000 \text{ cal.}} \times 100 = 64\% \text{ efficiency}$$

Figure 2.—Summary of energy balance and efficiency of oxidative phosphorylation.

endless but vitally energy-yielding cycle. The important net results of one such circuit are the complete oxidation of one molecule of 3-carbon pyruvate to 3 molecules of carbon dioxide and the accompanying release of chemical energy previously trapped in carbon-to-carbon bonds. These events and component reactions have been elaborately documented in minute detail by beautifully designed and skilfully executed experimental work at several levels of tissue complexity.

Yet the subsequent mechanisms of energy capture, storage, and effective coupling with contractile protein remain under an intensive investigative searchlight and frequently appear to elude complete exposure. Presumably, the released energy is captured in a singularly efficient manner as high energy phosphate (although recently reported by some workers to be less high in energy content than earlier believed[4]) in the form of ATP, by a series of cellular mechanisms whose mystery is camouflaged by the term oxidative phosphorylation. In any event, the combustion of two molecules of pyruvate, derived from one molecule of glucose, generates through oxidative phosphorylation at least 30 molecules of ATP, thus effectively trapping in usable form (from the standpoint of the muscle or myocardial fiber), a minimum of 345,000 calories (Figure 2). Since an additional 92,000 calories may be obtained by the glycolytic reactions from glucose to two pyruvates, and since the potential caloric equivalent of glucose is 686,000 calories, the entire complex series of events described attains remarkably high over-all efficiency, approximately 65 per cent[5]. Parenthetically, this high biochemical efficiency is not to be confused with the lower over-all work efficiency achieved by the contracting heart as it ejects its bolus of blood under pressure against pulmonary or systemic resistance.

The latter value for efficiency of cardiac work is variously estimated as 20 to 30 per cent.

The outline of intermediary metabolism of glucose encapsulated above is apparently fundamental to the biochemical operations of essentially all animal tissues, including the heart. The energetic aspects have been summarized here because appreciation of them is fundamental to any further development of any phase of cardiac metabolism, and because the story of the integration of this sweeping concept from numerous individual brilliant researches constitutes one of the major biochemical and physiological advances of the past thirty years. The Nobel Committee expressed tangible recognition of the lasting and fundamental impact of this research on medicine when in 1953 the Nobel Prize in medicine and physiology was awarded to two of the principal architects of this plan of biochemical energetics, Doctor H. A. Krebs of Oxford and Doctor Fritz Lipmann, formerly of Boston, now at The Rockefeller Institute for Medical Research.

The energy effectively stored in ATP must now be transferred in some controlled manner upon appropriate stimulus to the muscle fiber protein, under favorable ionic conditions, to effect contraction of the fiber. The terminal phosphate of ATP is apparently released directly to and is intimately concerned with the physical change of actomyosin which results in a shortened form of this contractile protein. This terminal phosphate of adenine nucleotide can then be replaced, through a phosphate transferring reaction, from the muscle's storage form of energy-yielding phosphate, phosphocreatine.

It must certainly not be assumed that these latter aspects of muscle energy transfer are as completely understood nor as uniformly accepted as the earlier reactions of the glycolytic and oxidative phases. For example, in very recent years evidence has come from two laboratories[6] which may be interpreted as casting some doubt upon the previously supposed certainty that ATP is the direct energy-containing participant in the contractile twitch of the muscle fiber. Thus elaborate experiments by Mommaerts and his group have failed to reveal the decrease in concentrations of ATP, phosphocreatine, or related substances expected to result from the early phases of a single contraction in a cooled, slowed turtle sartorius or gracilis muscle[6a]. In a similar vein of uncertainty, we are reminded that new forms and properties of muscle proteins have recently been discovered[7], which may leave

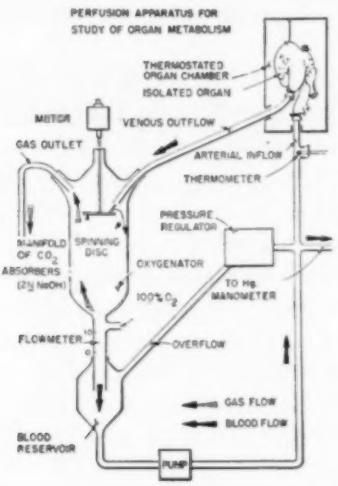

Figure 3.—Diagram of perfusion apparatus for study of carbon-labeled substrate metabolism in the isolated dog heart.

subject to modification the proposed alternative models describing the complex mechanism of muscle fiber contraction.

IV. Isotopic Studies of Cardiac Energy Sources in the Beating Heart

In the sequence of biochemical events leading to myocardial contraction which we have rapidly summarized, the obvious starting point is the delivery to intracellular metabolic sites of a mixture of potentially energy-yielding organic fuels. It is chemical energy stored within the atom-to-atom bonds of these fuels which ultimately is released and captured for conversion to the mechanical energy of muscle fiber contraction. Let us now return to this initial phase to examine selected portions of experimental evidence indicating relative roles of these carbon fuels as substrates for degradation to utilizable energy.

This question of the nature of the metabolic mixture most acceptable to the myocardium under various conditions has been approached experimentally in a wide variety of ways. Each technique has served its purpose of providing additional information concerning myocardial metabolism at some particular level of cellular complexity and functional viability. One such experimental level is that of the isolated,

blood-perfused animal heart (Figure 3), which can be sustained in a beating state for several hours, but which is devoid of many of the uncontrollable variables necessarily imposed by study of the heart in the intact animal. We have studied some metabolic characteristics of this preparation, as had others before us, with the aid of isotopic carbon labels incorporated into substrates selected for their reported importance in the metabolic fuel mixture supplying the heart its energy sources. We have followed the cardiac fate of these carbon 13- and carbon 14-labeled fuels with emphasis on two chemical and physiological questions: 1) What portion of the total metabolism of the beating heart can be accounted for as degradation of a given substrate, and 2) what is the role in cardiac metabolism of the major storage form of carbohydrate, glycogen?

V. Conversion of Carbon-Labeled Subtrates to Carbon Dioxide

In an attempt to obtain some quantitative answers to these questions, our laboratory group, including Dr. John A. Johnson, Dr. Nathan Lifson, Mrs. Ruth Deal, and Dr. Sang Don Rhee, injected into the circulation of an isolated beating dog heart preparation, perfused by recirculating heparinized blood, a carbon-tagged substrate: lactate, pyruvate, glucose, or one of the short chain fatty acids. In each case, analysis of the respiratory carbon dioxide produced by the heart over a two to four-hour perfusion period provided direct evidence for appreciable conversion of that substrate to the end product of carbon combustion, carbon dioxide. The percentage of the total respiratory output of carbon dioxide derived from the labeled compound injected varied with the particular compound, its concentration in blood circulating through the coronary bed, and the controlled conditions of the individual experiment. However, there did emerge certain apparent preferences and limitations of the intact, functioning myocardium for complete energy-yielding oxidation of each substrate tested.

The two-carbon fatty acid, acetate, whose crucial metabolic position in its active form acetyl CoA we have mentioned earlier, may account for 30 to 40 per cent of the total respiratory CO_2 produced by the intact and beating but isolated heart[8] (Table I). Similar results had been found several years earlier by Dr. Victor Lorber[9] at Minnesota and by Clarke[10] in England. Several words of qualification are

TABLE I. SHORT CHAIN FATTY ACID CONVERSION TO CO_2 BY THE ISOLATED PERFUSED DOG HEART AT FATTY ACID CONCENTRATIONS OF 12 TO 14 MILLIMOLES PER LITER

Fatty acid	*Concentration in water of blood plus heart millimoles/liter*	*% of CO_2 from labeled carboxyl %*	*% of CO_2 from labeled fatty acid* %*
Acetate	14.0	20	40
Propionate	12.6	5	15
Butyrate	12.8	3	12
Octanoate	12.0	3	24

*Assumes equal rates of combustion to CO_2 for all carbon atoms of compound.

necessary, however, lest these results be interpreted to mean that acetate or acetyl CoA is the all-important carbon source for cardiac production of chemical energy. Actually these figures, 30 to 40 per cent, were obtained only at inordinately high blood levels of injected carbon-tagged acetate, approximately 14 millimoles per liter. This concentration is at least 20 times greater than that normally present in circulating blood[11]. At much lower concentrations, 1 to 2 millimoles per liter, four short chain fatty acids compared, including acetate, accounted for a relatively small percentage of the heart's CO_2 production, approximately 5 per cent. The data from the labeled acetate experiments do emphasize, however, that the isolated beating heart has a great capacity for degrading large quantities of acetate or, presumably, the acetate-like two carbon fragments generated from glucose, pyruvate, or long chain fatty acids delivered to myocardial cells or biochemically produced within those cells. Thus data from the intact heart seem entirely consistent with the pivotal metabolic role firmly established for acetyl CoA in recent years by scores of well documented biochemical studies on less complex tissue preparations. In our heart preparation, other short chain fatty acids were also found readily oxidizable to carbon dioxide, but in varying degrees much less so than acetate. Bing and his group[12], using the catheterized coronary sinus as a sampling source for coronary venous blood in the intact human, have found several striking examples of high total fatty acid extraction from the coronary circulation. This was particularly true when circulating carbohydrate fuels available to the heart were decreased in concentration.

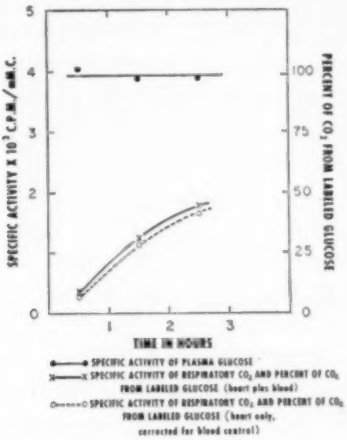
SPECIFIC ACTIVITY X 10³ C.P.M./mM.C.
PERCENT OF CO₂ FROM LABELED GLUCOSE
TIME IN HOURS
SPECIFIC ACTIVITY OF PLASMA GLUCOSE
SPECIFIC ACTIVITY OF RESPIRATORY CO₂ AND PERCENT OF CO₂ FROM LABELED GLUCOSE (heart plus blood)
SPECIFIC ACTIVITY OF RESPIRATORY CO₂ AND PERCENT OF CO₂ FROM LABELED GLUCOSE (heart only, corrected for blood control)

Figure 4.—Conversion of glucose-C^{14} to CO_2 by the isolated dog heart.

The carbon-containing substrates long considered most readily utilized for energy by the heart are lactate and glucose. Isolated heart experiments in which one of these compounds[13], or the closely related three-carbon intermediate pyruvate[14] was administered in the isotopically-labeled form (carbon 13 or 14) have confirmed the important contribution these materials make to the total energy metabolism of functioning myocardium. Glucose, for example, labeled with carbon 14 either in the first carbon or in all six carbons, and maintained by constant infusion at a normoglycemic level in the blood perfusing the isolated heart, may account for at least 50 per cent of the total CO_2 produced[15] (Figure 4). (In these experiments, values for labeled glucose conversion to carbon dioxide were corrected for the comparatively small glucose oxidation by formed elements in the circulating blood.)

VI. The Role of Glycogen in Cardiac Metabolism

Experimental results relating to the metabolic role of cardiac glycogen obtained from the series of studies described above may now be summarized. It has long been a point of investigative interest whether the glycogen of the heart represents a stored metabolically inert carbohydrate rarely involved in the mainstream of the chemical reactions outlined earlier, or whether it is continuously and rapidly turned over

TABLE II. CONVERSION OF PYRUVATE-2-C^{14} AND GLUCOSE-1-C^{14} TO GLYCOGEN IN THE ISOLATED PERFUSED DOG HEART

Labeled compound administered	*% of glycogen from compound %*	*Estimated rate of glycogen replacement % per hour*
Pyruvate-2-C^{14} (6)*	0.1 (range: 0.0 to 0.6)	———
Glucose-1-C^{14} (4)*	17.7 (range: 13.6 to 30.6)	6.4 (range: 4.5 to 7.7)

*Number of experiments included in mean values and range.

as an active participant in the metabolic mill[18]. In practically all of the experiments just described, where a carbon-labeled substrate was offered to the circulating blood sustaining an isolated dog heart, cardiac glycogen was routinely isolated and analyzed for its carbon 14 content as an indicator of the biochemical interconvertibility of the injected labeled substrate with heart glycogen.

Glycogen isolated from the hearts perfused with carbon-labeled lactate[13] or any of the short chain fatty acids[8] was uniformly lacking in detectable carbon label. (In these cases, the isotope used was the heavy carbon form, C^{13}, and therefore isotope dilution by the system can not be completely ruled out as the cause for negative results. However, calculations of possible dilution and isotope analysis factors make it seem unlikely that any appreciable conversion of lactate or fatty acids to heart glycogen occurred.) Carbon 14-tagged pyruvate, when administered to the isolated dog heart at abnormally high blood concentrations (0.5 to 6 millimoles per liter) did result in detectable but minimal glycogen labeling[14]. Less than one-half of one per cent of isolated glycogen carbon could be considered as derived from injected isotopic pyruvate (Table II).

Glucose, on the other hand, has yielded a strikingly contrasting result. During less than four hours of isolated heart perfusion up to 30 per cent of cardiac glycogen was replaced or supplemented by new glycogen formed from tagged blood glucose maintained at slightly greater than 100 milligrams per cent (a physiologically normal level) and a constant level of radioactivity[15]. On the assumption, reasonably well supported by analysis for glycogen of heart biopsy samples, that

total cardiac glycogen content remained essentially constant, this glycogen replacement can be described as a turnover rate of from 5 to 8 per cent per hour (Table II). In this calculation, cardiac glycogen is tentatively assumed to be metabolically homogeneous, an assumption undoubtedly less than valid in the light of recent studies on this question by the Stettens[16] and others. However, the summarizing point to be emphasized from these results on glycogen replacement in the isolated heart is that cardiac glycogen must not be considered metabolically inactive with respect to circulating blood glucose. On the contrary, rapid conversion of circulating glucose to heart glycogen occurs in the course of myocardial degradation of glucose to its ultimate chemical fate as carbon dioxide. Intermediates like pyruvate, lactate, or fatty acids far removed from glucose, metabolically speaking, do not appear to be readily convertible to cardiac glycogen, but are swept into other metabolic channels including oxidation to CO_2. Although various series of individual reactions are well known which might be expected to lead eventually from any of these compounds to glycogen, apparently the energy considerations and reaction conditions within the intact heart are not favorable for the rapid, appreciable conversion to glycogen from compounds as remote from or more remote from glycogen than pyruvate. Thus glucose, from the standpoint of the myocardial fiber as studied in our experiments, may still be considered the substrate *par excellence* for cardiac production of the storage carbohydrate glycogen or for complete energy-yielding oxidation to carbon dioxide.

VII. Experimental Acidotic Heart Failure and Some Agents Effecting Its Reversal

I would like now to refer to some experimental work perhaps less biochemical in nature than that described above but which illustrates how certain chemical or pharmacological agents can produce rather dramatic and profound effects on cardiac contractility studied in isolated heart preparations. Recently Dr. George Nahas, now at Walter Reed Army Institute of Research, and I investigated the adverse effects of high concentrations of carbon dioxide on the myocardium functioning as the conventional denervated heart-lung preparation[17]. When the lungs of this system, circulated by heparinized blood, were ventilated with 10, 15, or 30 per cent carbon dioxide in oxygen, within

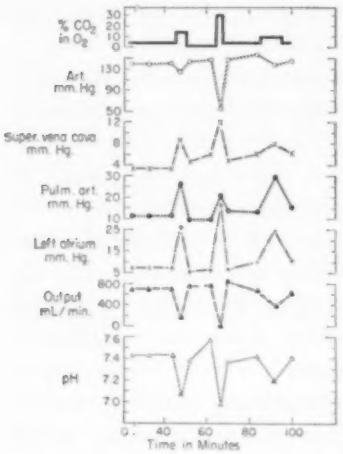

Figure 5.—Effect of 10, 15, and 30 per cent CO_2 in O_2 on hemodynamic variables in a representative experiment on the dog heart-lung preparation.

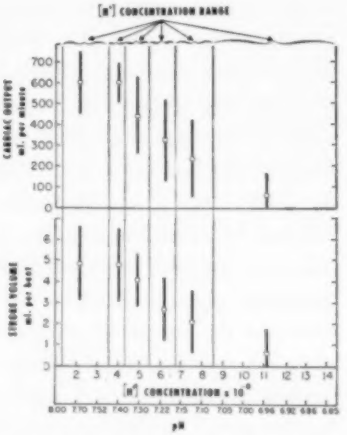

Figure 6.—Relation between hydrogen ion concentration (or pH) of coronary arterial blood and cardiac output (or stroke volume) of the dog heart-lung preparation ventilated by varying mixtures of CO_2 in O_2. Open circles indicate mean values of cardiac output or stroke volume for values of hydrogen ion concentration included in range groupings designated at the top of the diagram. Each value represents the average of at least 12 measurements. Solid vertical bars indicate standard deviations from the mean values.

two to four minutes there occurred a striking but reversible failure of the heart to maintain its control work load established on 5 per cent CO_2. The latter level had been selected for the control period because it maintains the arterial pH of the heart-lung preparation at its normal level, 7.4. Evidence for this acidotic heart failure on 15 or 30 per cent CO_2 consisted of a precipitous reduction of cardiac output against constant outflow resistance, elevated superior vena cava pressure, severe cardiac dilatation, a decline in outflow pressure, and a pronounced elevation of left atrial pressure (Figure 5).

Return to the control pH level of 5 per cent carbon dioxide, if not delayed too long, essentially reversed these depressant effects. If exposed to 30 per cent CO_2 and therefore to an arterial pH of about 6.9 for greater than 10 minutes, the lungs of the preparation exhibited severe pulmonary edema and the heart-lung would not regain its control

levels of functions when returned to the control gas mixture of 5 per cent CO_2 in O_2.

In Figure 6, a composite diagram of the relation between hydrogen ion concentration (or pH) and cardiac output or stroke volume indicates in graphical terms that the lower the pH produced by inhalation of a gas mixture relatively rich in CO_2, the more depressant its effect on the capacity of the heart to eject adequately during systole. A similar although less pronounced depressant effect was observed on heart rate. Evidence was obtained which indicated that acidotic heart failure produced in this manner was not a consequence of hypoxia or of inadequate coronary perfusion.

In prominent contrast to this prompt and severely depressant effect of CO_2-induced acidosis on the isolated heart is the remarkable capacity for tolerance of the intact animal (dog) to severe hypercapnia. This tolerance of the whole organism to 30 to 40 per cent carbon dioxide has been confirmed by several research groups and has been studied in great detail at the University of Minnesota by Brown and his collaborators[18]. This seemingly paradoxical difference in response to high carbon dioxide by the isolated, functioning heart on the one hand and the intact body on the other hand tempts one to speculate what pertinent compensatory factors may be operative on the acid-threatened myocardium when it is integrated with the remainder of the organism, but which are not present or able to counteract the deleterious effects of CO_2 on the unsuppported heart alone.

In some experiments which conceivably may have some bearing on this question, we administered various cardioactive agents to the heart-lung rendered acidotic and therefore acutely failing by inhalation of 10 or 15 per cent CO_2. In the case of each of several drugs tested, but with varying degrees of rapidity or effectiveness, the profound myocardial failure consequent to high CO_2 administration could be reversed or prevented by an empirically determined dosage of the particular cardioactive agent selected. Thus epinephrine or nor-epinephrine (Figure 7), acetyl strophanthidin (rapidly-acting digitalis), and hydrocortisone[19] were all found to be counteracting agents able, in the face of continuing high carbon dioxide levels and resulting low blood pH, to reverse the low cardiac output, high atrial pressures, falling arterial pressure, and cardiac swelling which had been observed following 15 per cent carbon dioxide inhalation. This reversal could be accom-

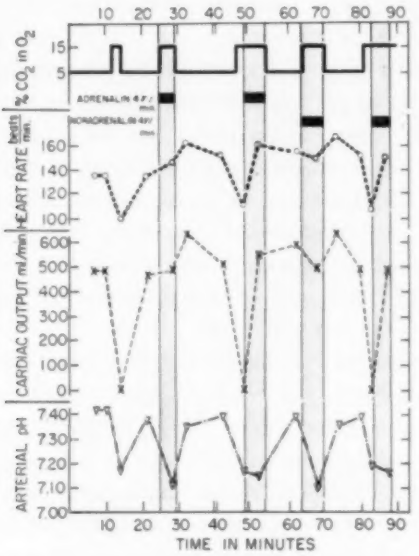

Figure 7.—Reversal of acidotic failure by epinephrine or nor-epinephrine infusion in the heart-lung preparation ventilation with 15% CO_2 in O_2.

plished by infusion of 4 micrograms of epinephrine or nor-epinephrine per minute (or 10 micrograms per kilogram over a five minute period of infusion), by 0.1 milligram of strophanthidin, or by 5 micrograms of hydrocortisone. At this time it is only a matter of conjecture which if any of these agents, or what possible combination of them, may be responsible for preventing the myocardium within the intact organism from suffering the severe failure of contraction observed so dramatically in the isolated heart threatened by acute hypercapnia. Yet we do know that each of these materials, with the possible exception of a digitalis-like derivative, is endogenous to a greater or lesser extent in the intact animal and may be called forth in increased quantity when the organism is subjected to stress, imposed in this case by abnormally high accumulation of carbon dioxide and the consequent acidosis.

Summary and Conclusion

In this discussion concerning selected aspects of myocardial biochemistry and physiology, we have sketched the fundamental sequence

of events which leads from cellular degradation of energy-yielding carbon compounds to the capture and efficient storage of that energy and eventually to the contractile shortening of myocardial protein. Data have been presented which illustrate the use of one experimental technique for verifying the relative importance to the myocardial energy economy of certain well-known substrates. The prominent role of glucose as a highly favorable fuel for myocardial oxidation has been documented in terms of its ready conversion to carbon dioxide by the isolated beating heart. In contrast to its once-supposed metabolic inertness, cardiac glycogen has been demonstrated to participate actively in metabolic affairs of the myocardium, at least in terms of the rapid replacement of heart glycogen by carbon-labeled circulating blood glucose.

To illustrate the profound effects of certain endogenous chemical agents on the contractile force of the functioning heart, we have reported the acute heart failure observed in the heart-lung preparation challenged by high alveolar and arterial concentrations of carbon dioxide. Further, we have described the rapid reversal or successful prevention of this acidotic heart failure by certain cardioactive agents including acetyl strophanthidin and such important endogenous substances as epinephrine, nor-epinephrine, and hydrocortisone.

Certainly it may be observed that the biochemist and physiologist find in the heart a fascinating contractile organ at once challenging and responsive to their laboratory inquiries into the fundamental characteristics of living tissue, but simultaneously often stubbornly resistant in yielding its innermost secrets to the investigative tools available to the research scientist.

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THE CONFEDERATE MEDICAL OFFICER IN THE FIELD*

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FIELD ORGANIZATION: The organization of the field and general hospital service of the Confederate medical department was interlocking at the top level during the first two years of the war. Surgeon-General Samuel P. Moore directed the activities of each, and in addition, the medical directors of armies and military departments had general control over all the medical officers and hospitals within the geographical limits of their commands. It was not until March 12, 1863, that a general order was issued by the Adjutant and Inspector-General's Office which altered this latter arrangement. Then general hospitals were removed from the jurisdiction of medical directors of armies and departments and placed under the authority of medical directors of hospitals[1].

Each army corps had a medical director who was immediately responsible to the medical director of the army. Altogether there were 18 medical directors on duty in September, 1864[2]. Medical directors, in addition to being generally responsible for medical officers and hospitals under their control, were required to prepare for the Surgeon-General two monthly reports: a consolidated report of the sick and wounded and a return of medical officers. Directly below medical directors in the chain of command came the chief surgeons of the various army divisions; these were appointed upon the recommendation of the medical directors and were free from all regimental duty. Right under the division in the army's organization was the brigade, and each brigade had a senior surgeon—not relieved from regimental service—to oversee its general well-being. Medical directors, chief surgeons of divisions, and senior brigade surgeons were directed to make such recommendations regarding the prevention of disease and the "construction and economy of the hospitals, and . . . the police of the camps, as may appear neces-

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sary for the benefit and comfort of the sick, and the good of the service"[3]. These officers, incidentally, were general—not personal—staff officers; hence they were not affected by personnel changes at the command level[4].

Each regiment generally had one surgeon and one assistant surgeon to minister to its sick and wounded. A bill to authorize the appointment of an additional assistant surgeon to each regiment, passed by Congress in August, 1861, was vetoed by President Davis on the ground that existing legislation was sufficient to meet regimental needs[5]. That all medical personnel did not agree may be seen in the view expressed a year later by Lafayette Guild, Medical Director of the Army of Northern Virginia, that every regiment should have at least two assistant surgeons. Guild also contended that senior surgeons of brigades ought to be relieved from regimental duties and that one or more assistant surgeons should be attached to each brigade as supernumeraries "for assignment to field hospitals and . . . to supply deficiencies continually arising from sickness and death of regimental medical officers"[6]. Records kept and reports made by medical officers in the field were very similar to those required of their counterparts in the general hospitals[7].

General army regulations allowed regiments in the field one steward, one cook, and one nurse for each company[8]. Hospital stewards, appointed by the Secretary of War, performed duties similar to those executed by stewards in general hospitals. They took charge of the hospital stores, supervised the cooks and nurses, and acted as medical dispensers and apothecaries. Hospital Steward George E. Waller of the Twenty-fourth Virginia Regiment, for example, was left in charge of the field hospital during the entire winter of 1864-1865[9, 10]. Nurses and cooks were usually detailed from the ranks[11], and a special committee appointed by the Provisional Congress to investigate the medical department complained of poor nursing and cooking in the camps. The establishment of both an army nurse corps and a number of bakeries was recommended by the committee, but neither of the suggestions was deemed to be feasible[12].

Medical officers in the field were faced with many problems similar to those in the general hospitals, and the regulations for the latter applied, as far as practicable, to the field service[13]. It should be pointed out, however, that after the early epidemics the number of sick in the field was never so troublesome and that most of the disabled were usually

transferred to the general hospitals. As a rule, the most important work of field medical officers pertained to camp sanitation and caring for the men during and immediately following an engagement. Those functions will receive particular emphasis in this paper.

Camp Sanitation: Regimental surgeons were responsible for finding out as much as possible about the sanitary condition of the camp site, learning of diseases common to the locality and the means which had been most successful in combating them, keeping a close watch over the clothing needs of the troops, maintaining proper police of the encampment, insisting on strict personal cleanliness, enforcing all hospital regulations, seeing that the water was pure, and suggesting necessary dietary changes[14]. Despite the sanitary regulations, however, actual conditions of camp police not infrequently manifested, to use the words of a Northern observer in describing Confederate hospitals at Gettysburg, "a deplorable want of cleanliness" and at times were "disgustingly offensive." [15] A Union army medical director, examining Confederate field hospitals during the Shenandoah Valley Campaign in late 1864, reported seeing "the most extreme filth and positive indications of neglect. . . ." [16] Confederate inspectors themselves also found police regulations disregarded at times and referred to the necessity of frequent camp inspections[17]. One inspector reported the ground surrounding a division hospital in Petersburg to be "offensive to the sight as well as the smell. In this important feature of cleanliness," he concluded, "there was evident and inexcusable neglect. . . ."

Directives concerning camp sanitation became increasingly strict as its importance became evident. A circular of the Second Brigade, Second Division, Army of Northern Virginia, dated August 3, 1862, ordered regimental commanders to publish and enforce all needful police regulations. Sinks were to be dug at once, and the men were to be compelled by posted sentinels to use them. Non-users were to be "severely punished." A patrol, in addition to the regular sentinels, was "to prevent the commission of nuisances within the camps." Offal was to be buried away from the camps[18].

Surgeon General Moore ordered "frequent inspections" each month and a sanitary report to division headquarters[19]. In the Army of Tennessee, pursuant to an order of January 8, 1864, the old guard was directed to clean the encampments daily while company details policed their grounds twice daily and stood inspection after each policing. The

brigade officer of the day was responsible for the proper placement and covering of sinks, the isolation of slaughter pens, the daily burning of offal, the policing of places where animals were kept, and for seeing "that nothing offensive to decency or detrimental to health be anywhere visible." [20] In August 1864 the Army of Northern Virginia's medical director instructed chief surgeons of divisions to make at least one inspection each week of the trenches occupied by their divisions. Chief surgeons and inspectors were directed "to confer and advise with the immediate commanders of troops, and, when deemed necessary, to make such suggestions, with reference to the observance of the laws of hygiene, as will prevent disease and promote the health and comfort of the soldier." [21]

Naval officers commanding vessels on the Savannah River received a general order in April 1863 that clothes should be washed three times weekly and hammocks twice each month. Bedding was to be aired when hammocks were washed[22]. When the army was in winter quarters there were usually regular cleaning days or "broom days." During a campaign such days took place during a lull in the fighting. On these occasions the men became almost stifled by the large clouds of dust which resulted from the sweeping and rearranging, but the over-all effect was probably beneficial—for the moment at least[23].

Responsibility for lax sanitary practices was often assigned to commanding officers in the field. Surgeon-General Moore, in a communication to the Secretary of War, dated October 18, 1861, charged regimental officers with failure to act on the suggestions of medical personnel in effectuating proper hygienic regulations, and he urged that all commanding officers be directed to see that police rules were scrupulously enforced by their subordinates[24]. Brigadier General Earl Van Dorn, commanding the Department of Texas in 1861, was accused of retaining Texan volunteers in an unhealthful location until practically all became diseased[25].

Surgeon J. Julian Chisolm, writing in 1862, excoriated commanding officers for their failure to appreciate the importance of good hygienic conditions. The Confederate Army would continue to suffer heavily from sickness and death, he contended, unless officers "take more interest in the general welfare of their men, and cease to consider professional advice offensive and intrusive. . . . The sick list," he added, "will offer a fair criterion of the military status of an officer and his capacity

for taking care of his men, which is one of the first rules in military science." [26] Observers sometimes noticed that vigorous enforcement of sanitary measures not only reduced sickness but greatly improved the discipline and spirit of the troops. It was asserted that General Lee's efforts along this line transformed the army which he took over from General Joseph E. Johnston, after the latter was wounded at Fair Oaks, from a mutinous and dissatisfied mob into a well-organized, hard-fighting military machine[27]. There is no question but that when commanders insisted on the frequent striking of tents, the punishment of every man who refused to use properly located privy vaults, the careful disposal of the excreta of the sick, and the correct placement of stables and pens for livestock, the salutary results were clearly evident[28].

Field Routines: Medical officers in the field held surgeon's call, or sick call, early every morning. In the Army of Tennessee sick call was made 15 minutes after reveille, and the ailing of each company were marched to the hospital by a non-commissioned officer detailed daily for such duty[29]. William H. Taylor, a medical officer, wrote of the procedure in his regiment as follows:

> "Diagnosis was rapidly made, usually by intuition, and treatment was with such drugs as we chanced to have in the knapsack and were handiest to come at. In serious cases we made an honest effort to bring to bear all the skill and knowledge we possessed, but our science could rarely display itself to the best advantage on account of the paucity of our resources. On the march my own practice was of necessity still further simplified, and was, in fact, reduced to the lowest terms. In one pocket of my trousers I had a ball of blue mass, in another a ball of opium. All complainants were asked the same question, 'How are your bowels?' If they were open I administered a plug of opium, if they were shut I gave a plug of blue mass." [30]

The supply table authorized the issuance of tents for field hospital purposes[31], but medical officers were sometimes unable to produce them. It was reported late in the summer of 1861 that because of the scarcity of tents farm houses were seeing service as hospitals all along the Potomac[32], and the next summer General Lee requested division commanders, if possible, to establish their field hospitals in rented houses rather than tents[33]. Most surgeons favored the use of tents over buildings, however, and some believed them to be more conducive to recovery than the general hospitals[34]. Included among the latter group was Charles S. Tripler, Medical Director of the Union Army of the Potomac[35]. Surgeon General Moore's sentiments on this subject were

reflected during the summer of 1863 by his order that three large tent hospitals be established near Staunton and Winchester to receive all those sick and wounded from the Army of Northern Virginia who required only "temporary assistance"[36].

Medical officers in the field had a considerable amount of time on their hands when the army was not in motion, and some, unable to obtain professional literature and increase their knowledge of medicine in that way, spent their free time writing letters, seeking out attractive members of the fair sex, attending religious services in the camp, and promoting various other social activities[37]. Occasionally medical societies were formed, and the members thereof met to discuss medical and surgical subjects. At least one such group had a dissecting hut which was fitted up by the surgeon of a Mississippi regiment. "We could easily procure subjects from beyond the lines," wrote a member of this society, "and we thought it legitimate to use them for scientific and educational purposes"[38].

Battle Preparations: Careful preparations were made by medical officers in the field on the eve of expected battles. Medical Director Lafayette Guild ordered that each division medical wagon should transport 150 pairs of drawers, the same number of shirts, 50 blankets, a supply of tea, and some dessicated vegetables to make soup; these items were for the use of wounded during and after a battle[39]. Guild pointed out, in explaining this order, that the clothing of wounded soldiers almost always had to be cut off to facilitate treatment, and even when that was not the case, he added, it was "improper to permit the wounded men to remain in clothes rendered offensive and stiffened with blood." Guild also explained that men suffering from wounds and loss of blood were extremely sensitive to cold even in the summer and thereby needed the warmth afforded by blankets[40]. It is interesting to note that many men on naval vessels removed most of their clothing prior to an engagement; other preparations on board ship included a distribution of tourniquets to division officers and a thorough sanding of the decks "to prevent slipping after the blood should become plentiful." [41]

The medical director of general hospitals, in close contact with the army medical director, attempted as a rule to clear all hospitals near the expected battle site of those who could bear transportation to more distant institutions, and he advised the army medical director as to the number of vacant beds available in each of the hospitals under his juris-

diction[42]. At times, due to army movements, it was necessary to relocate general hospitals[43]. As the battle became imminent, brigade field infirmaries, identifiable by hospital flags, were established; to the extent practicable, these were located in buildings outside the range of shells, but strategically enough to maintain constant communication with both the front and the rear of the army[44]. Brigade medical personnel and supplies were sometimes consolidated for the purpose of setting up division infirmaries[45].

The Infirmary Corps: An infirmary corps, comprising about 30 detailed men—usually the "least effective under arms"—and the assistant surgeon from each regiment, was responsible for the care of the wounded upon the field and for the removal from the field of those unable to walk. The assistant surgeon, who was in charge of the infirmary corps, was to equip himself with a pocket case of instruments, ligatures, needles, pins, chloroform, morphine, alcoholic stimulants, tourniquets, bandages, lint, and splints. All members of the infirmary corps were unarmed and wore a badge to distinguish them from the rest of the command. They were outfitted with one litter to every two men, and each member carried a canteen of water, a tin cup, and a knapsack; the latter was supposed to contain lint, bandages, sponges, tourniquets, four splints, and a pint bottle of alcoholic stimulants. The corps members accompanied the ambulance and were charged with following the action upon the battlefield[46].

The infirmary corps was no place for cowards. As it advanced with the troops the assistant surgeon kept on the lookout for places suitable as first aid stations; due notice was taken of the topography and gullies deep enough to afford welcome protection were especially sought after. Work done by the corps was usually rather simple, but the members were kept very busy. According to one who served as an assistant surgeon in the field, their service

> ". . . consisted chiefly of the application of plaster and bandages and the administration of stimulants, and superintending the placing of the badly wounded in the ambulances for transportation to the field hospital. No elaborate surgical procedure was undertaken unless there was urgent necessity for it. Sometimes a very extended area was fought over, and wounded men, both our own and the enemy's, would be scattered about it, often, if the country was wooded or otherwise difficult, in out-of-the way places, whither they had wandered. When the battle was ended, if our troops had possession of the field, we had to hunt up these unfortunates—a duty willingly performed, though not infrequently an arduous one." [47]

It was especially arduous when the woods caught on fire as occurred during the battles of Chancellorsville and the Wilderness. A vivid picture of the former's aftermath was related as follows by a participant:

> ". . . On the left side of our line . . . the scene beggars description. The dead and badly wounded from both sides were lying where they fell. The woods, taking fire that night from the shells, burnt rapidly and roasted the wounded men alive. As we went to bury them we could see where they had tried to keep the fire from them by scratching the leaves away as far as they could reach. But it availed not; they were burnt to a crisp. The only way we could tell to which army they belonged was by turning them over and examining their clothing where they lay close to the ground. . . ." [48]

At the Wilderness the infirmary corps was seriously impeded in its work by the flames and smoke; undoubtedly many wounded men there were cremated also as a result[49].

Members of the infirmary corps were forbidden to engage in any action which was not strictly in the line of duty; the medical officer was specifically enjoined not to devote his exclusive attention to a wounded officer or leave his post to escort him to the rear. Troops other than the infirmary corps were not permitted to break ranks to care for the wounded or remove them from the field; those who did were liable to receive harsh punishment[50]. Field commanders were always proud when they could boast in their battle reports that "no soldier left the field unauthorized"[51].

The Field Infirmary During Battle: While the assistant surgeons were occupied in attending the wounded on the field, the surgeons remained at the brigade or division infirmaries and administered to those whom the ambulances or litter carriers brought in. Their ministrations consisted of performing all necessary surgical operations, seeing that proper nourishment in sufficient quantities was provided by the cooks, and directing the movement of the disabled from the infirmaries to the general hospitals[52].

Amputations and other surgical operations were supposed to be performed at the field infirmaries with the least possible delay, and this procedure was usually followed[53]. The Surgeon-General, in an effort to increase the strength of the field operating staff, directed, early in 1864, that a Reserve Surgical Corps be organized by medical directors of hospitals for temporary field duty during emergencies. Medical directors were to appoint surgeons to the reserve corps on the basis of one for every five hundred beds in their departments. Those appointed to

the corps were to be skillful in the use of the knife, and field medical directors were authorized to request their services whenever they were needed[54]. Lafayette Guild's inability to obtain the services of as many members of the reserve corps as he requested during the heavy fighting in the Wilderness (May 5-12, 1864) caused him to express the fear that they were "too anxious to return to their hospitals"[55]. Such comments reflect the almost contemptuous attitude sometimes manifested by field surgeons toward those assigned to general hospitals. "As for the disease to which you refer, as being the chronic condition of the 'Hospital Doctors' ", wrote one of the former, "I am satisfied it is *incurable*. I only regret it is not mortal"[56]. Surgeon Samuel H. Stout, Medical Director of the General Hospitals of the Army and Department of Tennessee complained bitterly of the field medical officers' lack of confidence in the labors of their fellows in the general hospitals. "Were the same spirit of recrimination manifested toward surgeons in the field by the surgeons in hospitals," he wrote, "few regimental or brigade or division surgeons in this army could do much else than defend themselves against accusations brought almost every day against them by privates in hospitals"[57].

The scenes in and around field hospitals during an engagement were quite grim. One soldier who visited a field hospital near Atlanta during the summer of 1864 remembered years later the sight of a large pile of arms and legs in the rear of the building and stated that there was nothing in his whole life that he remembered with "more horror than that pile of legs and arms that had been cut off our soldiers"[58]. He concluded his comments on the hospital as follows:

> "It was the only field hospital that I saw during the whole war, and I have no desire to see another. Those hollow-eyed and sunken-cheeked sufferers, shot in every conceivable part of the body; some shrieking, and calling upon their mothers; some laughing the hard, cackling laugh of the sufferer without hope, and some cursing like troopers, and some writhing and groaning as their wounds were being bandaged and dressed. I saw a man . . . who had lost his right hand, another his leg, then another whose head was laid open, and I could see his brain thump, and another with his under jaw shot off; in fact, wounded in every manner possible." [59]

To make matters more difficult, hospitals sometimes were caught in the line of fire and both surgeons and patients were killed[60].

The dead, of course, were buried as soon as possible after a battle by burial parties from the opposing armies. A short truce was usually agreed upon after an engagement to enable the armies to recover the

bodies, and their interment, in common graves dug for the dead of each army, took place immediately. General Lee, according to Lafayette Guild, readily gave his consent to the removal of enemy dead because "he did not want a single Yankee to remain on our soil *dead* or *alive*"[61]. The offensive odor of dead around the works at Vicksburg and other besieged garrisons created a sanitary problem, and it was sometimes reported that, without a formal truce, Federal skirmishers fired on burial parties[62]. Occasionally, when the army was forced to withdraw after a battle, the dead were left on the field[63].

Movement to General Hospitals: The Ambulance Problem. After the wounded had received the necessary attention at the field hospitals, the surgeons were responsible for directing the removal of those who had undergone operations, and were able to stand further movement, to the general hospital[64]. Ambulances and every other means of wagon transportation were used to transport the wounded to railroad depots, steamer landings, and sometimes the entire distance to the interior institutions. This movement was often handicapped seriously by the lack of a sufficient number of ambulances and animals to draw them, two of the truly serious shortages experienced by medical officers of the Southern Confederacy.

Lafayette Guild could report, even after the bloody battles of the Wilderness and Spotsylvania (May, 1864), that there was no suffering among the men from the lack of medical supplies or surgical attention[65]. And an abundance of medical stores and officers was reported at other times by inspectors and high ranking surgeons in the field[66]. Never, however, did the armies appear to have an adequate amount of ambulance transportation, and in April, 1863, Guild reported that one of the two most serious problems confronting the Army of Northern Virginia as a whole was that of transportation[67]. The lack of ambulances sometimes made it necessary for Guild to keep his wounded in the field[68]; and he complained that the wagons he had were made of inferior materials whereas "the horses appear to have been broken down before turned over to the ambulance train"[69]. Guild believed that each regiment should have two ambulances and that an additional number should be held in reserve for each corps and the whole army[70]. He was unable ever to procure a sufficient number, however, and continued to complain of the ambulance trains' "wretched conditions"[71]. In June, 1863, when Lee's forces invaded Pennsylvania, spring wagons were impressed

so that the sick could be carried forward with the army[72].

The shortage of ambulance transportation was felt throughout the Confederacy. Thomas Williams, Medical Director of the Army of the Potomac, wrote of the need for ambulances in his army, asserted that poor materials were being used in those that were furnished, and asked that the War Department adopt regulations necessary to prevent the use of hospital wagons for ordinary regimental purposes[73]. When the special congressional committee appointed to investigate the Medical Department completed its inquiry early in 1862, it asserted that the lack of medical wagons had "produced much of the mortality and much of the suffering"[74]. A year later, inspecting officers reported only 38 ambulances in the Army of Mississippi[75], the Army of Tennessee's medical director informed Surgeon-General Moore that his army had received "an inadequate supply"[76] and Lieutenant-Colonel E. J. Harvie, Assistant Inspector-General in the Army of Mississippi, adverted to the need for surgical instruments in that army but emphasized quite clearly that "ambulances, particularly are required and ought if possible to be supplied"[77].

Transportation facilities confronting medical personell in the Army of Tennessee became increasingly serious, and early in 1864 its medical director warned "that not half the necessary supplies can be carried and those who are so unfortunate as to be sick or wounded on a march, will have to be left by the roadside"[78]. In the summer of that year, Medical Inspector Edward N. Covey found the ambulance transportation of Medical Director Stout's department to be "entirely insufficient"[79]. And in 1865, entire brigades in the Department of Western Virginia and East Tennessee were found to be without ambulances or medical wagons of any kind[80]. Priorities assigned to the use of wagons for purposes of forage and the movement of subsistence stores during the closing weeks of the war made the problem of transporting medical and hospital supplies almost insoluble[81].

The wounded usually underwent a most uncomfortable trip even when ambulance transportation was available to move them from the field hospitals. Some spring vehicles were supplied early in the war, but when these broke down they were replaced by ordinary wagons[82], and as the latter moved over rough, wooded country or on roads rutted by artillery and army supply trains the occupants experienced a rude jolting. Heavy downpours sometimes caused wagons to become mired

in the mud, while, at the same time, the wounded were drenched by the rain falling through leaky covers[83]. Drivers were not always considerate of their charges, and one officer related that he was compelled to draw his pistol on one to stop him from traveling at breakneck speed over the roughest roads[84].

Ambulance wagons might also be harassed by the enemy. Two ambulance trains headed south after the battle of Gettysburg were both, according to Lafayette Guild, attacked by enemy raiding parties. The raiders, he asserted, "destroyed many wagons," "paroled the wounded private soldiers," and took with them "all of the officers who fell into their hands"[85]. When the Gettysburg wounded reached Williamsport, they were moved across the swollen Potomac on rafts and ferry boats; an ambulance line was then organized to Staunton which made connections with the Richmond trains. Not all, however, were removed to the capital. Many convalesced in the Valley hospitals[86].

Field medical officers of the Army of Northern Virginia were aided to a considerable extent in the removal of their wounded to the general hospitals by an organization known as the Richmond Ambulance Committee. Established in the capital during the spring of 1862, it was composed for the most part of men exempt from military duty and had an over-all membership of nearly a 100 well-known citizens. Headed by John Enders, the committee formed itself into a military company and attempted, at its own expense, to attend, feed, and transport the wounded to the interior hospitals[87]. At the battle of Williamsburg (May 5, 1862), the organization had 39 ambulances on the field, and it functioned effectively in almost every engagement participated in by Lee's army. Seven thousand men passed through the committee's hands at Chancellorsville (May 2, 1863), and after the battle of Gettysburg, a Richmond newspaper reported that

> " . . . the Ambulance Corps was in Winchester for the entire period of three weeks, at the expense of many thousands of dollars to its individual members, caring for the wounded, facilitating their transportation, and doing all possible offices of humanity." [88]

Coordination existed between the Ambulance Committee and the medical directors of the Virginia general hospitals and the Army of Northern Virginia[89]. Lafayette Guild and General Lee both acknowledged publicly the great obligations they were under to the committee for its valuable and humane services[90].

Transportation of the Wounded by Rail: As a general rule, ambulance transportation was used only to remove the wounded to nearby railroad and water connections. A good many disabled soldiers reached the Richmond hospitals in ambulances or on steamers from Drewry's Bluff, but most wounded throughout the Confederacy were transported by rail. In the decade preceding the war the Southern states had been quite active in railroad construction, and by 1860 Virginia and Georgia ranked sixth and seventh, respectively, among all the states in railroad mileage. The enterprise shown by these two states was fortunate for the Confederacy in moving its disabled troops since their strategic location caused a large share of the burden to fall upon their lines [91].

The movement by rail was at times a most disagreeable experience for the wounded and a trying one for medical officials. After the battle of Chancellorsville, for example, Union cavalry tore up the railroad tracks in the Confederate rear and occasioned a delay of several days in the transportation of the disabled to Richmond[92]. Unheated cars in winter also caused suffering; the wounds of a group that reached Richmond late in November, 1863, on an unheated ambulance train were almost frozen, and the Ambulance Committee "built a fire on the track" to relieve the intense suffering[93]. It was not unusual for trains to jump the track, and the wounded often died or received additional injuries in such wrecks. A Texan who was wrecked en route to the Stout Hospital in Milledgeville, Georgia, wrote: "I went all through the Tennessee campaign, and I tell you that I saw some hard times, and then to get nearly killed on an old car, is rather disheartening."[94] Inspectors complained also of lack of water in the cars and the tendency of engineers to jerk the cars in starting their trains. "Another evil," wrote an inspector late in 1863, "is in the frequent and most unreasonable delays of trains loaded with sick and wounded; in the present crowded and confused condition of transportation, it is doubtful whether we can effect any removal of this difficulty"[95]. Such delays were indeed unavoidable, and a surgeon of the Mississippi Blind Asylum Hospital in Jackson noted that some of the wounded received there were almost "in articulo mortis" when they arrived[96]. Medical Director A. J. Foard of the Army of Tennessee held General Leonidas Polk responsible for much of the suffering borne by the disabled sent back from Murfreesboro because Polk would not allow them to stop at Chattanooga, and Foard spoke of that officer as being "very obstinate"[97].

Chickamauga: The problems involved in the large-scale movement of wounded men to the general hospitals and the utter impossibility under certain circumstances of preventing much tragic suffering and very many deaths may perhaps best be illustrated by the efforts of the medical officers to care for the Chickamauga wounded. In the first place, the wounded had to be moved from 10 to 25 miles over bad roads from the battlefield to the railroad. Rail transportation was at first deficient, and it was reported five days after the battle that there were still 20 carloads of men waiting to be moved. In the meantime, Medical Director Stout had lost contact with the medical director of the Army of Tennessee, but, learning where the wounded were being concentrated along the railroad, he repaired from Marietta to that point with additional medical officers and hospital attendants to supervise the further care and disposition of the wounded. Other hospital surgeons were sent to the field, and they were replaced by private physicians, many of whom volunteered their services to the government during the emergency. After Stout arrived on the scene, he found it necessary to open hospitals at Dalton and Ringgold and to reopen the Tunnel Hill institution; these points were located approximately 14, 8, and 12 miles, respectively, from the area where the wounded were concentrated and were primarily receiving and distributing centers for the patients. Since the hospitals in Stout's department had a capacity of only about 7,500 beds it was necessary to send large numbers of the wounded to other departments; many were assigned to the care of private citizens residing near the hospitals, and furloughs were granted to those who would be disabled for more than 30 days but who did not require skilled surgical attention. The slightly wounded were sent to convalescent camps, and malingerers were returned to their commands. Unfortunately, however, chiefly because of the rail situation, most of the wounded, regardless of ultimate destination, had to be sent to Atlanta. According to Surgeon J. P. Logan, medical officer in charge of the Atlanta hospitals, more than 10,000 soldiers were received into the hospitals of Atlanta during September alone whereas the capacity of those institutions was not more than 1800. To make matters worse, the hospitals below Atlanta were just in the process of being re-opened after their removal from the Chattanooga area. Both Logan and Stout were of the opinion that the medical officials had done well under the circumstances, but the latter communicated to Surgeon-General Moore his need for in-

creased hospital accommodations and more qualified medical officers[98].

Ordinarily the movement of the disabled to general hospitals took place with much more facility. Almost 5000 wounded men, for example, were received into the Richmond hospitals between May 6 and May 20, 1864, and the total number of deaths during that interval of time was reported as exactly 73. Of this number, it was revealed, 10 were dead upon arrival, 17 died within an hour after their reception, and 14 died within six or seven hours after admission[99]. The reception of wounded from the Army of Northern Virginia at Richmond was superintended by Francis W. Hancock, surgeon in charge of Jackson Hospital, and a military guard stood by to prevent any interference with the men. Only Surgeon Hancock, his immediate aides, and the Ambulance Committee were authorized to attend the disabled[100].

Problems of Coordination: Two important factors that seriously handicapped the Medical Department in removing the sick and wounded to the rear before, during, and after engagements should be noticed. The first of these concerned a lack of proper staff cooperation between the Medical, Subsistence, and Quartermaster Departments. The second was the failure of the military arm to advise the Medical Department of troop movements.

Surgeon-General Moore, in an effort to solve the problem of insufficient staff coordination, proposed to the heads of the Subsistence and Quartermaster Departments in November, 1863, that special commissary and quartermaster officers, subordinate only to their seniors in Richmond, be appointed solely for the purpose of supplying the needs of the sick and wounded. It was Moore's contention that during active operations the duties of the chief commissary and quartermaster officers were so onerous and the lines of communication with their juniors were broken so frequently that proper services simply were not afforded medical officers. No response appears to have been forthcoming, and, late in January, 1864, the Surgeon-General appealed to field commanders themselves to perfect the best arrangement possible and enclosed his own proposition for their information[101]. No comprehensive plan was adopted, but an arrangement was made in Lee's army near the close of 1863 whereby an assistant commissary in each division gave his entire attention during the battles toward providing subsistence for the sick and wounded[102].

The medical directors of both the Army of the Potomac and the

Army of Northern Virginia complained at times of their inability to make adequate plans for the removal of the disabled because of the commanding general's failure to advise them of operations. Thomas H. Williams, medical chief of the Army of the Potomac, complained that unless the commander was "less reserved in his official intercourse with this Department, untoward circumstances will prove of frequent recurrence"[103]. Lafayette Guild wrote on one occasion that "everything is done hurriedly and mysteriously" and declared that a knowledge of contemplated troop movements "would add greatly to the efficiency of the Corps"[104].

Treatment of Enemy Captives: Large numbers of enemy sick and wounded often fell into Confederate hands after engagements, and their treatment was one of the problems of the battlefield. Usually enough Federal medical officers were left to render surgical attention to their troops, but, of course, much supervision and material aid was almost always needed. Many Union troops, for example, were so badly wounded in the terrible battle of Malvern Hill (July 1, 1862) that they could not be removed from the field. General Lee, made aware of their suffering, directed Lafayette Guild to assist the Northern surgeons in concentrating their men at a central position "where surgical aid could be more efficiently rendered and where provisions and other necessaries could be issued"[105]. Arrangements were sometimes made which allowed the United States commander to send supplies for his wounded[106], and it was not unusual, under agreement between the field commanders, for the disabled to be paroled and transferred within the Union lines as speedily as possible[107]. Others were transported to interior hospitals to receive treatment and await parole there. Surgeons of Confederate prison hospitals were ordered, in the spring of 1864[108], not to transfer any man whose life would be endangered by travel.

Confederate forces were not infrequently charged by the enemy with barbarous conduct in their treatment of Union sick and wounded. Colonel Abel D. Streight, who led a Federal raiding party from Tuscumbia, Alabama, toward Rome, Georgia, in April, 1863, asserted that the Confederates, after taking possession of the hospitals he had established for his wounded, seized the medical stores, instruments, blankets, rations, shoes, coats, hats, and money from the surgeons and left the wounded "in a semi-naked and starving condition"[109]. Several charges were made to the effect that Confederate officers refused to grant re-

quests, made under flag of truce, for the removal of Union dead and wounded from the field of battle[110]. Such accusations as were made usually condemned the offenders with violating well-recognized principles of war[111].

There was undoubtedly some mistreatment and neglect of sick and wounded captives by both Confederate and Union forces. Neither side, at any rate, enjoyed a monopoly of accusations against the other. Lafayette Guild, for example, held that "the inhuman enemy invariably, when an opportunity offers, drag our sick and wounded officers (at the sacrifice of their lives) into their own lines"[112]. Charges and counter-charges notwithstanding, Union officers themselves have testified to many refreshing instances of human attention accorded their disabled by Southern medical officers. John Swinburne, left in charge of the Federal sick and wounded remaining on the field after the "Seven Days" (June 25-July 1, 1862), informed General Lee that the Confederate surgeons had "performed miracles in the way of kind attention both to us surgeons as well as the wounded"[113]. A detail of United States surgeons sent within the Southern lines after the battle of Chancellorsville (May 2, 1863) to effect the removal of their men related that the "rebel surgeons . . . treated our wounded with consideration"[114]. During the Wilderness campaign some 600 Union troops were rescued from hospitals inside the Confederate lines, and Montgomery C. Meigs, Quartermaster General of the United States, informed the Secretary of War that the men were in "generally good condition" and had been "kindly treated by the enemy"[115]. Thomas A. McParlin, medical head of the Union Army of the Potomac, reported, after the battle of Cold Harbor (June 3, 1864), that the Federal wounded collected in Confederate field hospitals received the same amount of food, medical attendance, and medical supplies as the Southern wounded[116].

The kind of treatment of many Confederate wounded who fell into Union hands on land and sea has also been attested by Southern officers and other observers. When Lee abandoned his positions at Antietam, for example, many wounded were left behind, and the kindness of the doctors in blue to those wounded received wide recognition. Jonathan Letterman, the Union army's medical director, expressed the sentiment of most army medical officers in the following statement: "Humanity teaches us that a wounded and prostrate foe is not then our enemy"[117].

Exchange of Surgeons: An extremely significant development pertaining to the status of medical officers captured on the field of battle occurred in the spring of 1862. During the opening campaigns of the war, captive surgeons, in accordance with the practice that had prevailed throughout the world, were held prisoners in the same manner as other officers. Most medical officers, as well as other military personnel, dreaded captivity, and, when their armies were compelled to retreat after an engagement, there was an understandable reluctance on their part to remain with the wounded and face months of confinement in enemy prisons. Their incarceration, generally speaking, meant that many sick and wounded comrades would be deprived of their services over an indefinite period of time. When Stonewall Jackson, during his Shenandoah Valley campaign of 1862, entered the city of Winchester on May 25, however, a train of events was set in motion that inaugurated a new departure in the annals of war.

A number of Union wounded had been left at Winchester's Union (Hotel) Hospital in charge of J. Burd Peale, a brigade surgeon, and seven other Federal medical officers. General Jackson ordered that Peale and his colleagues be allowed to continue their ministrations undisturbed, and before Jackson's forces withdrew from the city on May 31, an agreement was entered into between the Union surgeons and Hunter Holmes McGuire, medical director of Jackson's army, which freed the former unconditionally, upon their promise to work for the release of the same number of Confederate surgeons. The Union surgeons also agreed to lend their efforts to win support for the principle that all medical officers captured thereafter should be released unconditionally[118].

The agreement of May 31, 1862, between the Union medical officers and Medical Director McGuire at Winchester was followed by a proposal on June 10, 1862, from General George B. McClellan, Commander of the United States Army of the Potomac, to General Lee, that medical officers "be viewed as non-combatants" and not liable to detention as prisoners of war[119]. General Lee concurred in this proposition on June 17, 1862[120]. Two days later, General McClellan sent General Lee a copy of General Orders No. 60, dated June 6, 1862, issued by the Adjutant General's Office in Washington, paragraph 4 of which reads as follows:

"The principle being recognized that medical officers should not be held

as prisoners of war it is hereby directed that all medical officers so held by the United States shall be immediately and unconditionally discharged." [121]

The precise relationship between this directive and the Winchester agreement is not known but certainly an important step in the interests of the sick and wounded of both armies had been taken. Complete harmony on the subject was apparently reached when the Confederate Adjutant and Inspector General's Office published General Orders No. 45 on June 26, 1862, which, like its Northern counterpart, directed the immediate and unconditional discharge of all medical officers in Southern prisons[122].

Release of medical officers pursuant to the foregoing orders proceeded without interruption until the summer of 1863. At that time the orders were suspended due to ill feeling which developed from the case of Dr. William P. Rucker[123]. Dr. Rucker, a staunch Unionist native of Covington, Virginia, was charged by the Commonwealth of Virginia with having committed murder and stolen a horse shortly after the outbreak of hostilities. On July 25, 1862, Confederate cavalry forces captured Rucker, who by that time it seems was a surgeon in the Union army, stationed at Summersville, West Virginia. Rucker was then delivered for trial to the state authorities. Robert Ould, the Confederate Agent of Exchange, refused to consider demands for Rucker's release or to concur in a proposal which would have permitted the exchange of all medical officers held by both sides with the exception of Rucker and a hostage held for him by the United States. The dreary controversy over Rucker dragged on until October, 1863, at which time he escaped from the state authorities in Richmond. On November 11, 1863, Ould accepted a Union proposal for the immediate release of all medical officers without reservation[124], and the free exchange of surgeons was resumed[125].

Cases continued to arise from time to time of the detention of Confederate medical officers by the United States, and these were sometimes attributed to the "maladministration of subordinate officers"[126]. The detention of medical officers for months at a time in such institutions as the Old Capitol Prison in Washington[127], the Military Prison Hospital in Louisville, Kentucky[128], and United States Military Prison No. 21 in New Orleans[129], however, probably could not be blamed altogether on subordinates. And eight Southern surgeons were detained for four months in Chattanooga Hospital No. 2—during

which time all of their wounded had been exchanged[130]. Records indicate also that medical officers of the United States were sometimes subjected to undue detention in the Confederacy[131].

Medical officers on both sides were always anxious for the speedy exchange of all prisoners, and the case for the neutralization of hospitals, their personnel and material was stated by no one any more ably than it was by Surgeon Henry S. Hewit of the United States Medical Department in January, 1865. Hewit, Medical Director of the Army of Ohio, wrote:

> "The hospital should, under all circumstances, be held sacred. Surgeons and attendants engaged in their legitimate duties should not be subject to capture, and hospital stores and medicines should have free transit and enjoy freedom from capture or confiscation. The question is of the utmost importance in its most obvious view in saving life and mitigating suffering on the field of battle, and taking away the necessity for sudden and most distressing removals of wounded men according to the exigencies of conflict. . . . It would do more than any measure, either military or political, to realize the desire of every patriot—the restoration of an harmonious Union." [132]

Surely the field surgeon should have been accorded, in the interests of humanity, the utmost consideration. He endured the long marches with the troops and shared their peril on the field of battle. His hospital frequently fell into the line of fire, and, during the din of battle and after, he was called upon to perform hour after hour the most serious operations. The casualties of major battles were so heavy that neither the Confederate surgeon nor his Northern counterpart ever had enough assistance at times, and his labors in behalf of the wounded often continued until he was overcome by exhaustion. Battlefield promotions and other rewards might be won by the fighting man, but there was little likelihood that the field surgeon, regardless of his risk and work, would receive more than passing notice[133].

REFERENCES AND NOTES

1. *The War of the Rebellion: A Compilation of the Official Records of the Union and Confederate Armies*, 127 vols. and index (Washington, 1880-1901), Ser. II, Vol. II, 425: hereafter cited as *Official Record of the Union and Confederate Armies*.
2. *Confederate States Medical and Surgical Journal*, (Richmond, 1864-65), I (September, 1864), 152. Ordinarily, according to General Orders No. 23, February 25, 1863, the senior surgeons of commands entitled to medical directors were detailed as medical directors, but the directive provided that when the interests of the service required, the Surgeon General would recommend medical directors. Robinson,

R.H.P. (comp.), *General Orders . . . For the Year 1863 . . .* (Richmond, 1864), 21.

3. *Official Records of the Union and Confederate Armies,* Ser. IV, Vol. I, 1024-1025.
4. *Ibid.,* Vol. II, 56.
5. *Journal of the Congress of the Confederate States of America,* 1861-65, 7 vols. (Washington, 1904-05), I, 370-71; hereafter cited as *Journal of the Congress.*
6. *Official Records of the Union and Confederate Armies,* Ser. I, Vol. XI, Pt. 2, 501.
7. *Regulations for the Army of the Confederate States, 1863* (Richmond, 1863) 239-240.
8. *Ibid.,* 240; *Regulations for the Medical Department of the Confederate States Army* (Richmond, 1861-63) 7.
9. Chisolm, J. Julian. *A Manual of Military Surgery,* (Charleston, 1861), 70. See also *Regulations for the Medical Department of the Confederate States Army,* 6; *Regulations for the Army of the Confederate States, 1863,* 238.
10. G. E. Waller to his sister, October 7, 1864, George E. Waller Letters (University of North Carolina Library).
11. Chisolm, *A Manual of Military Surgery loc. cit.* 1, pp. 71-72. Band members sometimes served as nurses. Davis, Nicholas A. *The Campaign from Texas to Maryland (*Richmond, *1863),* 127. A few women went into the field to nurse the disabled, and the Catholic sisterhoods were quite active in this respect. See Hal Tutwiler to "Cousin Netta," September 2, 1861, Tutwiler Papers (University of North Carolina Lirary); George Barton, *Angels of the Battlefield.* (Philadelphia, 1898, 2nd ed.).
12. *Journal of the Congress,* I, 725.
13. *Regulations for the Army of the Confederate States, 1863,* 239.
14. Chisolm, *A Manual of Military Surgery,* 123-24.
15. Moore, Frank (ed.), *The Rebellion Record . . .,* 11 vols. and supplement (New York, 1861-68), VII, 127.
16. *Official Records of the Union and Confederate Armies,* Ser. I, Vol. XLIII, Pt. 1, 142.
17. *Ibid.,* Ser. I, Vol. XLIII, Pt. 2, 1274.
18. Order Book, Headquarters Second Brigade, Second Corps, Army of Northern Virginia, April-October, 1862 (Confederate Museum, Richmond).
19. SGO Circular, May 24, 1864. This item was found in Letters, Orders, and Circulars Sent and Received, Medical Director, Army of Tennessee, 1863-1865. War Department Collection of Confederate Records, Chap. VI, vol. 642 (The National Archives); hereafter cited as WD Coll. of CR.
20. *Official Records of the Union and Confederate Armies,* Ser. I, Vol. XXXII, Pt. 2, 532.
21. L. Guild to his chief medical officers, August 6, 1864, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1863-1865, WD Coll. of CR, Chap. VI, Vol. 642.
22. *Official Records of the Union and Confederate Navies in the War of Rebellion,* 30 vols. and index (Washington, 1894-1927), Ser. I, Vol. XIV, 691.
23. Benjamin Washington Jones, *Under the Stars and Bars. A History of the Surry Light Artillery* (Richmond, 1909), 78; William J. H. Bellamy Diary, July 15, 1862. (University of North Carolina Library); Diary of Richard Woolfolk Waldrop, August 28, 1863, *ibid.*
24. *Official Records of the Union and Confederate Armies,* Ser. IV, Vol. I, 692-693.
25. Davis, *The Campaign from Texas to Maryland,* II.
26. Chisolm, J. J. *Manual of Military Surgery,* 3-5. Field surgeons were known to have voiced their opposition to orders that might affect the health of the soldiers. One brigade commander was told by his senior surgeon that "We must use prophylactic and hygienic measures to preserve the health of our army, and not attempt to cure men who are made sick by improper management." *Official Records of the Union and Confederate Armies,* Ser. I, Vol. XXII, Pt. 2, 1126.

27. Cook, Joel. *The Siege of Richmond . . .* (Philadelphia, 1862), 246-47.
28. Bedford Brown, "Personal Experience in Observing the Results of Good and Bad Sanitation in the Confederate States Army," *The Southern Practitioner* (Nashville, 1879-1918), XV (November, 1893), 448; hereafter cited as "Personal Experience".
29. *Official Records of the Union and Confederate Armies,* Ser. I, Vol. XXXII, Pt. 2, 530-532.
30. William H. Taylor, *De Quibus* (Richmond, 1908), 316.
31. *Regulations for the Army of the Confederate States, 1863,* 284.
32. Richmond *Examiner,* September 9, 1861. Some regiments were unable to obtain any tents. Samuel Garland to General James Longstreet, August 8, 1861. Letters Received by Surgeon Thomas H. Williams, WD Coll. of CR, Chap. VI, Vol. 369.
33. *Official Records of the Union and Confederate Armies,* Ser. I, Vol. XI, Pt. 3, 637. Ailing officers were sometimes quartered in private homes. J. McF. Gaston to his wife, April 13, 1863, James McFadden Gaston Papers (University of North Carolina Library).
34. Hunter Holmes McGuire, one of Lafayette Guild's medical directors, was in agreement with this point of view. See Joseph Jones, "Observations," *Richmond and Louisville* Medical Journal, IX (June, 1870), 640. See also Chisolm, *Manual of Military Surgery,* 71.
35. *Official Records of the Union and Confederate Armies,* Ser. I, Vol., V, 79.
36. Moore to W. A. Carrington, June 26, 1863, Letters, Orders, and Circulars Sent, Surgeon General's Office, WD Coll. of CR, Chap. VI, 740. Hospital tents were fourteen feet wide, fifteen feet long, and eleven feet high; one could accommodate from eight to ten patients. Several tents could be joined together. Chisolm, *Manual of Military Surgery,* p. 67.
37. Burnett, Edmund C. (ed.), "Letters of a Confederate Surgeon: Dr. Abner Embry McGarity, 1862-65", *Georgia Historical Quarterly* (Savannah, 1917-) XXIX (September, 1945), 174, 180-82. Masonic lodges were operating in some camps. *Ibid.,* (December 1945), 227.
38. L. J. Wilson, *The Confederate Soldier* (Fayetteville, Arkansas, 1902), 171.
39. Guild to H. H. McGuire, April 9, 1864, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1863-1865, WD Coll. of CR, Chap. VI, Vol. 642.
40. Guild to S. P. Moore, *ibid.*
41. Scharf, J. Thomas. *History of the Confederate States Navy* (New York, 1887), 311.
42. Many of the wounded of the battle of Chickamauga were sent by rail to Marietta. To make room at Marietta, the sick in hospital there were sent back to Atlanta, and those in the Atlanta hospitals were moved back to La Grange and other points. Atlanta Southern *Confederacy,* quoted in Richmond *Examiner,* September 28, 1863. See also C. H. Tebault, "Hospitals of the Confederacy," *The Southern Practitioner,* XXIV (September, 1902) 499-500.
43. S. H. Stout to S. P. Moore, October 10, 1863, copy, Stout Papers, microfilm Reel IIB (University of North Carolina Library).
44. *SGO Circular,* May 7, 1862, Letters Sent and Letters, Orders, and Circulars Received, General Hospital No. 1, Savannah, Georgia, 1862-1864, WD Coll. of CR, Chap. VI, Vol. 648; Wilson, *The Confederate Soldier,* 104-105. See also J. B. Clifton Diary, *passim,* Archives of the North Carolina Historical Commission.
45. *SGO Circular,* May 7, 1862, WD Coll. of CR, Chap. VI, vol. 648.
46. Ibid. It has been said that Hunter Holmes McGuire, medical director of Stonewall Jackson's commands, "perfected" the ambulance or infirmary corps in the spring 1862.
47. Taylor, *De Quibus,* 330.
48. John O. Casler, *Four Years in the Stonewall Brigade* (Marietta, Georgia, 1951), 151.
49. G. Moxley Sorrel, *Recollections of a*

Confederate Staff Officer (New York and Washington, 1905), 251.

50. See, for example, *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XIV, 883; *ibid.*, Vol. XXXVIII, Pt. 4, 672.
51. *Ibid.*, Vol. XI, Pt. 1, 566.
52. *SGO Circular*, May 7, 1862, WD Coll. of CR, Chap. VI, vol. 648.
53. *Ibid.*; *Official Records of the Union and Confederate Armies*, Ser. I, Vol. X, Pt. 2, 533. The wounded of the battle of First Manassas, instead of receiving surgical attention on the field, were sent to the general hospitals for treatment. Field surgeons were warned against repetition of this procedure. T. H. Williams to corps medical directors, November 13, 1861, Letters Sent by Surgeon Thomas H. Williams, Medical Director, Army of the Potomac, WD Coll. of CR, Chap. VI, Vol. 367.
54. SGO Circular, March 15, 1864, copy, Letters Sent and Letters, Orders, and Circulars Received, General Hospital No. 1, Savannah, Georgia, 1862-1864, WD Coll. of CR, Chap. VI, Vol. 648. W. A. Carrington, medical director of the Virginia hospitals, and Lafayette Guild, medical director of Lee's army, did not see eye to eye on some matters. Carrington proposed early in 1863, for example, that medical officers be detached from field regiments and assigned to hospital service after battles. Guild contended that further engagements would probably occur and that field officers could not be spared. One purpose of the Reserve Surgical Corps' formation was to enable regimental medical officers to remain in the field. Guild to S. P. Moore, May 22, 1863, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1862-1863, WD Coll. of CR, Chap. VI, Vol. 641.
55. Guild to J. E. Clagett, May 19, 1864, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1863-1865, WD Coll. of CR, Chap. VI, Vol. 642. Guild proposed, early in 1865, that some system of rotation be devised so that all medical officers could have both hospital and field experience. Guild to Moore, January 9, 1865, *ibid.*
56. R. T. Breckinridge to H. H. McGuire, February 1, 1863, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1862-1863, *ibid.*, Vol. 641.
57. Stout to ?, April 28, 1863, copy, Reel IIB, Stout Papers.
58. Watkins, Sam R. *"Co. Aytch," Maury Grays, First Tennessee Regiment . . .* (Jackson, Tennessee, 1952), 193.
59. *Ibid.*
60. Heartsill, W. W. *Fourteen Hundred and 91 Days in the Confederate Army . . .* (Jackson, Tennessee, 1954), 96.
61. Guild to S. P. Moore, May 22, 1863, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1862-1863, WD Coll. of CR, Chap. VI, Vol. 641. See also Casler, *Four Years in the Stonewall Brigade*, 89, 140.
62. *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XXIV, Pt. 1, 89; *ibid.*, Pt. 3, 1002-1003.
63. See, for example, Dr. James E. Green, Diary, July 3, 1863 (University of North Carolina Library).
64. Guild advised the Surgeon General after the battle of Chancellorsville that 132 wounded men were not able to bear movement to the railroad depot. Guild to Moore, May 22, 1863, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1862-1863, WD Coll. of CR, Chap. VI, vol. 641.
65. Guild to Moore, June 7, 1864, *ibid.*, 1863-1865, Vol. 642.
66. Guild to Moore, April 14, 1863, *ibid.*, 1863-1865, Vol. 641; J. McF. Gaston to his wife, April 16, 1863, James McFadden Gaston Papers; *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XLII, Pt. 2, 1271.
67. Guild to A. H. Cole, April 11, 1863, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1862-1863, WD Coll. of CR, Chap. VI, Vol. 641. See also J. McF. Gaston to his wife, April 16, 1863, James McFadden Gaston Papers. General regulations allowed each regiment two four-wheeled and two two-wheeled ambulances, but these paper allowances never materialized into actuality. *Regulations for the*

Army of the Confederate States, 1863, 284.

68. Guild to Moore, September 6, 1862, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1862-1863, WD Coll. of CR, Chap. VI, Vol. 641.
69. Guild to Moore, November 22, 1862, *ibid.*
70. Guild to Moore, April 9, 1864, *ibid.*, 1863-1865, Vol. 642.
71. Guild to Moore, May 22, 1863, *ibid.*, 1862-1863, Vol. 641. See also *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XIX, Pt. 2, 660; *ibid.*, Vol. XXV, Pt. 2, 820. There was an ambulance manufactory in Richmond at the foot of 17th Street. Richmond *Daily Enquirer*, November 26, 1863.
72. J. McF. Gaston to his wife, June 27, 1863, James McFadden Gaston Papers.
73. Williams to A. C. Myers, February 8, 1862, Letters Sent, Medical Director's Office, Army of the Potomac, WD Coll. of CR, Chap. VI, Vol. 460; Williams to S. P. Moore, April 17, 1862, *ibid.* See also *Official Records of the Union and Confederate Armies*, Ser. I, Vol. IV, 667.
74. *Journal of the Congress*, I, 725.
75. *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XVII, Pt. 2, 844.
76. E. A. Flewellen to S. P. Moore, July 27, 1863, copy, Letters, Orders, and Circulars Sent and Received, Medical Director, Army of Tennessee, 1863-1865, WD Coll. of CR, Chap. VI, Vol. 748. The shortage of ambulances at Chickamauga delayed the removal of the wounded from the field. Frank M. Dennis to S. H. Stout, October 22, 1863, Stout Papers, Reel IIB.
77. *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XVII, Pt. 2, 844.
78. A. J. Foard to Stout, February 17, 1864, Stout Papers, Reel IIB.
79. E. N. Covey to Stout, July 14, 1864, *ibid.*, Reel IIA.
80. *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XLIX, Pt. 1, 982. There was also an early ambulance shortage in the Union army. *Ibid.*, Vol. III, 275; George E. Cooper, Medical Director of the United States Army of the Cumberland, averred late in 1864 that "the animals belonging to the ambulance trains have passed over twice as much ground as those of any other train in the army." *Ibid.*, Vol. XXXVIII, Pt. 1, 179. Well-built wagons and strong, perfectly conditioned animals were required for the field service.
81. Guild to S. P. Moore, March 1, 1865, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1863-1865, WD Coll. of CR, Chap. VI, Vol. 642.
82. Miller, Francis T. (ed.), *The Photographic History of the Civil War*, 10 vols. (New York, 1911), VII, 258. See also Chisolm, *Manual of Military Surgery*, 97-98.
83. Dr. Charles C. Gray, Diary, July 31, 1861 (University of North Carolina Library); Dr. James E. Green, Diary, September 8, 1864; *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XIX, Pt. 2, 606; Cook, *The Siege of Richmond*, 36.
84. Beale, George William. *A Lieutenant of Cavalry in Lee's Army (Boston*, 1918), 199.
85. *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XXVII, Pt. 2, 326-327.
86. *Ibid.*, 327. Richmond *Examiner*, July 14, 1863; Burnett (ed.), "Letters of a Confederate Surgeon," *loc. cit.*, XXIX (September, 1945), 162.
87. Richmond *Dispatch*, December 12, 1897, quoted in *Southern Historical Society Papers* (Richmond, 1876-), XXV (1897), 113; Richmond *Daily Enquirer*, September 26, 1863; Joseph T. Durkin (ed.), *John Dooley, Confederate Soldier, His War Journal* (Washington, 1945), 161.
88. Richmond *Examiner*, March 19, 1864.
89. W. A. Carrington to John Enders, April 18, 1864, Letters Sent and Received, Medical Director's Office, Richmond, Virginia, 1864-1865, WD Coll. of CR, Chap. VI, Vol. 364.
90. Guild to S. P. Moore, May 22, 1863,

Letters Sent, Medical Director's Office, Army of Northern Virginia, 1862-1863, *ibid.*, Vol. 641; *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XXVII, Pt. 3, 873. The Ambulance Committee even directed the movement of prisoners at times. Richmond *Examiner*, January 21, 1864.

91. Regular ambulance trains connected Virginia hospital centers throughout the war. General Lee and his medical director preferred the hospitals in Gordonsville, Charlottesville, Lynchburg, Danville, Staunton, and Farmville to those of Richmond, and they insisted that their sick and wounded be sent to those points when possible. See, for example, Guild to S. P. Moore, November 26, 29, 1862, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1862-1863, WD Coll. of CR, Chap. VI, Vol. 641; Guild to Surgeon Moffatt, June 5, 1863, *ibid.*
92. V. W. Harrison to W. D. Somers, May 14, 1863, William D. Somers Papers (Duke University Library). See also Edward A. Moore, *The Story of a Cannoneer under Stonewall Jackson* (Lynchburg, 1910), 127.
93. Richmond *Examiner*, December 1, 1863.
94. Mrs. S. E. D. Smith, *The Soldier's Friend* . . .(Memphis, 1867), 293-294.
95. S. M. Bemiss to Stout, November 28, 1863, Stout Papers, Reel IIB.
96. W. D. Somers to "friends," September 24, 1862, William D. Somers Papers. General Earl Van Dorn, Commanding General of the Army of West Tennessee at the battle of Corinth, Mississippi (October 3-4, 1862), was charged by a brigade commander, among other things, with having caused great suffering among the wounded in their movement after the battle. Van Dorn, it was asserted, "did allow one or more trains of cars, freighted with wounded soldiers from the battlefield . . . to be detained without any necessity at Water Valley, Mississippi, during one or more entire nights, said wounded soldiers having been herded in said cars at Holly Springs without blankets or nourishment and many with undressed wounds, no surgeon, officer, nurse, or attendant with them. . . ." *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XVII, Pt. 1, 416. A Court of Inquiry, headed by Major General Sterling Price, found Van Dorn innocent of such allegations, however. *Ibid.*, 459.
97. A. J. Foard to Stout, December 12, 1862, Stout Papers, Reel III.
98. Frank M. Dennis to Stout, October 22, 1863, *ibid.*, Reel IIB; Stout to S. P. Moore, October 10, 1863, copy, *ibid;* Wiley M. Baird to Stout, October 22, 1863, *ibid.*, Reel IIA; J. P. Logan to Stout, October 4, 1863, *ibid.;* Logan to Stout, October 24, 1863, *ibid.*, Reel III.
99. Richmond *Examiner*, May 21, 1864. Of 837 wounded received at the Seabrook Hospital in Richmond during a two-day period after the battle of Fredericksburg (December 13, 1862), only one was reported to have died. *Ibid.*, December 16, 1862.
100. "Instructions for the Reception and Transportation of Sick and Wounded from the Army of Northern Virginia," Letters Sent and Received, Medical Director's Office, Richmond, Virginia, 1864-1865, WD Coll. of CR, Chap. VI, Vol. 364.
101. S. P. Moore to Generals Longstreet, Polk, Pickett, Whiting, and Johnston, January 29, 1964, Letters, Orders, and Circulars Sent and Received, Medical Director, Army of Tennessee, 1863-1865, WD Coll. of CR, Chap. VI, Vol. 748.
102. *Ibid.* (enclosure marked "C"). Medical Director Stout advised the Surgeon General that his "chief difficulties in opening, closing & removing hospitals grow out of the want of prompt, active and zealous cooperation on the part of the Q. Masters and Subsistence departments. When hospitals are removed, it is often the case that they are for weeks without aid from these departments." Stout concluded with the statement that the Medical Department, with all its shortcomings, "can justly claim to be under better discipline and better organized than any of the staff

departments of this army." Stout to Moore, October 10, 1863, copy, Stout Papers, Reel IIB.

103. Williams to Moore, April 16, 1862, Letters Sent, Medical Director's Office, Army of the Potomac, WD Coll. of CR, Chap. VI, Vol. 460. See also Williams to T. G. Rhett, April 22, 1862, *ibid.*

104. Guild to Moore, November 22, 1862, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1862-1863, *ibid.*, Vol. 641.

105. *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XI, Pt. 3, 633. See also *ibid.*, 630.

106. See, for example, *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XXV, Pt. 2, 786; *ibid.*, Vol. XXXVI, Pt. 1, 221; *ibid.*, Ser. II, Vol. VIII, 437.

107. Guild to R. H. Chilton, July 26, 1862, Letters Sent, Medical Director's Office, Army of Northern Virginia, 1862-1863, WD Coll. of CR, Chap. VI, Vol. 641. Guild to Chilton, September 9, 1862, *ibid.*; Guild to J. Letterman, May 14, 1863, *ibid.*; *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XXV, Pt. 2, 447, 786. The transfer of wounded was a humane action. Major General Henry W. Halleck, General-in-Chief of the Union forces, asserted that it was "impossible for our own medical officers after a battle to attend the sick and wounded prisoners, and usually it is impossible for some weeks to hire citizen surgeons for that purpose." *Official Records of the Union and Confederate Armies*, Ser. II, Vol. IV, 102.

108. W. A. Carrington to G. W. Semple, April 12, 1864, Letters Sent and Received, Medical Director's Office, Richmond, Virginia, 1864-1865, WD Coll. of CR, Chap. VI, Vol. 364.

109. *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XXIII, Pt. 1, 293.

110. *Ibid.*, Vol. XXXV, Pt. 1, 301; *ibid.*, Vol. XL, Pt. 2, 210-211.

111. *Ibid.*, Ser. II, Vol. V, 471; *ibid.*, Vol. VI, 566-569. See also *ibid.*, Ser. I, Vol. XL, Pt. 3, 699.

112. *Ibid.*, Ser. I, Vol. XXVII, Pt. 328.

113. *Ibid.*, Ser. II, Vol. IV, 798. See also Cook, *The Siege of Richmond*, 219.

114. *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XXV, Pt. 1, 402-403.

115. *Ibid.*, Vol. XXXVI, Pt. 2, 854.

116. *Ibid.*, Pt. 1, 222. See also *ibid.*, Vol. XII, Pt. 1, 708.

117. *Ibid.*, Vol. XIX, Pt. 1, 112. Confederate disabled and their medical officers left at Gettysburg also received much attention from Medical Director Letterman and the United States Sanitary and Christian Commissions. Simon Baruch, one of the Southern surgeons who remained with the wounded, reported that he was given a six-mule wagon loaded to capacity with commissary and medical stores. Baruch, *Reminiscences of a Confederate Surgeon* (New York [?], 1915), 6. See also Baruch, "A Surgeon's Story of Battle and Capture," *Confederate Veteran* (Nashville, 1893-1932) XXII (December, 1914), 546. Such kindness extended to the war on the sea. The wounded of the *Alabama*, famous Confederate cruiser that was sunk by the *Kearsarge* (June 19, 1864), were taken on board the latter vessel for treatment. *Official Records of the Union and Confederate Navies*, Ser. I, Vol. III, 67-70. Admiral Franklin Buchanan, who commanded the Confederate naval forces in the battle of Mobile Bay (August 5, 1864), reported that his captive wounded were carried to the United States Naval Hospital at Pensacola, Florida, and received much consideration. *Ibid.*, Vol. XXI, 578.

118. The initiative in proposing the unconditional release of the Union surgeons seems to have been taken by Hunter McGuire. General Jackson's official campaign report is silent in regard to this important arrangement. See *Official Records of the Union and Confederate Armies*, Ser. II, Vol. IV, 799; Ashburn, "Hunter Holmes McGuire," in *Dictionary of American Biography*, 21 vols. and index (New York, 1928-45), XII, 59; "A Sketch of the

Life and Career of Hunter Holmes McGuire, M.D., LL.D., Surgeon, Physician, Teacher, Patriot," *Southern Historical Society Papers*, XXVIII (1900), 273. The written agreement signed at Winchester has not been located, but Philip Adolphus, one of the Union surgeons, made a copy of the document, and this copy was given to the Society of Medical History of Chicago when he died. George H. Weaver, "Surgeons as Prisoners of War," *Bulletin of the Society of Medical History of Chicago*, IV (January, 1933), 249.

119. *Official Records of the Union and Confederate Armies*, Ser. II, Vol. III, 671.
120. *Ibid.*, Vol. IV, 45.
121. *Ibid.* "Instructions for the government of armies of the United States in the field," issued as General Orders No. 100, dated April 24, 1863, stated in part that the "enemy's chaplains, officers of the medical staff, apothecaries, hospital nurses and servants if they fall into the hands of the American Army are not prisoners of war unless the commander has reasons to retain them." *Ibid.*, Vol. V, 674.
122. *Ibid.*, Vol. IV, 789. Such an order had been issued embracing the Department of Northern Virginia (Lee's command) on June 22, 1862. *Ibid.*, Ser. I, Vol. XI, Pt. 3, 612; *ibid.*, Ser. II, Vol. IV, 784. A Union observer noted that after the new arrangement "many Federal surgeons remained behind, and their services were very much appreciated by the men [left on the field]." Cook, *The Siege of Richmond*, 313-314.
123. See, for further information on the Rucker case, *Official Records of the Union and Confederate Armies*, Ser. II, Vols. IV, V, VI, *passim*.
124. *Ibid.*, Vol. VI, 501.
125. There were, according to a Richmond newspaper, 115 Confederate surgeons exchanged immediately after the accord reached in November. Richmond *Examiner*, November 27, 1863. The same newspaper, sometime earlier, had stated upon the basis of information supplied by "a recent arrival from the North," that there were 65 medical officers confined at Fort McHenry, 26 at Fort Delaware, 4 or 5 at Johnson's Island, and 3 or 4 at Gettysburg. *Ibid.*, October 9, 1863. W. A. Carrington declared that 32 medical officers who remained with the Gettysburg wounded were imprisoned. Carrington to A. W. Whitney, August 19, 1863, Order and Letter Book of the Confederate Medical Director (Confederate Museum). See also Richmond *Daily Enquirer*, September 26, 1863. Nineteen Union surgeons were being held in Libby Prison during July, 1863. *Ibid.*, July 22, 1863.
126. *Official Records of the Union and Confederate Armies*, Ser. II, Vol. VII, 141.
127. *Ibid.*, 481.
128. *Ibid.*, Vol. VIII, 156.
129. Bartlett, Catherine Thom, (ed.). *"My Dear Brother": A Confederate Chronicle* (Richmond, 1952), 160-61, 171.
130. *Official Records of the Union and Confederate Armies*, Ser. II, Vol. VII, 853. See, for other cases of unwarranted detention, *ibid.*, 825; *ibid.*, Vol. VIII, 193.
131. See, for example, *Official Records of the Union and Confederate Navies*, Ser. I, Vol. XV, 505; Scharf, *History of the Confederate States Navy*, 649 (footnote).
132. *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XXXVIII, Pt. 2, 536. A resolution offered by Horatio W. Bruce of Kentucky, which instructed the House Committee on the Medical Department to inquire into the feasibility of establishing neutral prison hospitals at the most important prison depots in both the Confederate States and the United States, was adopted by the Confederate House of Representatives on February 5, 1864. Journal of the Congress, VI, 758-759. There the matter rested.
133. For comment by a Confederate surgeon on his work during and after the battle of Chancellorsville, see Burnett (ed.), "Letters of a Confederate Surgeon," *loc. cit.*, XXIX (June, 1945), 104, 108. See also, for an account of

enemy shells bursting around a field hospital, *Official Records of the Union and Confederate Armies*, Ser. I, Vol. XI, Pt. 1, 742. A splendid tribute to the Union field surgeon is to be found in Moore (ed.), *The Rebellion Record*, VII, 128. Some surgeons combined military action with their medical duties, and there are quite a few accounts of heroism on the field of battle. Not all were fearless, however. When shells started falling near the *Arkansas*, a Confederate ram, its long, slim surgeon from Mississippi, according to a veteran of the war, could be heard to groan: "Oh Louisa and the babes!" C. W. Read, "Reminiscences of the Confederate States Navy," *Southern Historical Society Papers*, I (May, 1876), 357.

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It may not be generally known to Fellows of the Academy that the Library has an outstanding collection of medical portraits: some 10,200 separate ones mounted and about 139,300 catalogued in books and journals. It goes without saying that a picture of every Academy Fellow ought to be found here, and Fellows are invited to send the Library their photographs, if one is not already on file here. Any size is acceptable, from the vest-pocket up to the cabinet photograph. It is important that it be a clear print and a good likeness. Further, pictures of any other physicians for which Fellows wish to find a repository will be a welcome addition to the Library's collection.

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OCTOBER 13 to 17, 1958

RESEARCH CONTRIBUTIONS TO CLINICAL PRACTICE

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RESEARCH CONTRIBUTIONS TO CLINICAL PRACTICE

PANEL MEETING — 3:30 P.M.

Monday October 13

THE DIAGNOSIS AND MANAGEMENT OF CEREBRAL VASCULAR DISEASES

Chairman: IRVING S. WRIGHT, *Cornell University Medical College*

LECTURES — 8:30 P.M.

STUDIES OF CONTRACTILE PROTEINS OF MUSCLE

ANDREW G. SZENT-GYORGYI, *Institute for Muscle Research*

THE METABOLISM OF THE ERYTHROCYTE

IRVING M. LONDON, *Albert Einstein College of Medicine, Yeshiva University*

STUDIES OF THE LE CELL AND THE LE FACTORS

HENRY G. KUNKEL, *The Rockefeller Institute for Medical Research*

PANEL MEETING — 3:30 P.M.

Tuesday October 14

INFLUENZA AND UPPER RESPIRATORY INFECTIONS

Chairman: WALSH McDERMOTT, *Cornell University Medical College*

LECTURES — 8:30 P.M.

HEREDITARY ASPECTS OF DISEASE

BARTON CHILDS, *The Johns Hopkins University School of Medicine*

CONGENITAL DISEASES OF BLOOD PROTEINS

CHARLES A. JANEWAY, *Harvard Medical School*

HEREDITARY DISEASES OF CONNECTIVE TISSUE

VICTOR A. McKUSICK, *The Johns Hopkins University School of Medicine*

PANEL MEETING — 3:30 P.M.

Wednesday October 15

GLOMERULONEPHRITIS AND PYELONEPHRITIS

Chairman: WILLIAM GOLDRING, *New York University College of Medicine*

LECTURES — 8:30 P.M.

SOME MECHANISMS OF BACTERICIDAL CHEMOTHERAPEUTIC ACTION

BERNARD D. DAVIS, *Harvard Medical School*

THE NEW YORK ACADEMY OF MEDICINE

SECOND ANNUAL POSTGRADUATE WEEK

OCTOBER 13 to 17, 1958

RESEARCH CONTRIBUTIONS TO CLINICAL PRACTICE

LECTURES — 8:30 P.M. (continued)

Wednesday October 15 *(continued)*

OBSERVATIONS ON THE NATURE OF STAPHYLOCOCCAL INFECTIONS
DAVID E. ROGERS, *Cornell University Medical College*

THE CONTROL OF STAPHYLOCOCCAL SEPSIS
CARL W. WALTER, *Harvard Medical School*

PANEL MEETING — 3:30 P.M.

Thursday October 16

POTASSIUM THERAPY
Chairman: SAUL J. FARBER, *New York University College of Medicine*

LECTURES — 8:30 P.M.

HEPATIC CIRCULATORY PHYSIOLOGY
STANLEY E. BRADLEY, *College of Physicians and Surgeons, Columbia University*

JAUNDICE AND BILIRUBIN METABOLISM
RUDI SCHMID, *Harvard Medical School*

MANAGEMENT OF PORTAL HYPERTENSION
ARTHUR B. VOORHEES, Jr., *College of Physicians and Surgeons, Columbia University*

PANEL MEETING — 3:30 P.M.

Friday October 17

THE RADIATION HAZARD
Chairman: J. E. RALL, *National Institutes of Health*

LECTURES — 8:30 P.M.

THE FATE OF SODIUM AND WATER IN THE RENAL TUBULES
HOMER W. SMITH, Sc.D., *New York University College of Medicine*

MECHANISMS OF RENAL TUBULAR TRANSPORT
JOHN V. TAGGART, *College of Physicians and Surgeons, Columbia University*

ELECTRON MICROSCOPY OF THE KIDNEY IN NORMAL AND DISEASED STATES
JOHANNES A. G. RHODIN, *New York University College of Medicine*

SCIENTIFIC EXHIBIT

The Scientific Exhibit will open officially at 11 a.m. WEDNESDAY, OCTOBER 8, 1958 and be open daily 10 a.m. to 10 p.m. through October 17 except Saturday and Sunday, October 11 and 12.

MONTHLY PANEL MEETINGS FOR THE GENERAL PHYSICIAN

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(Please note: For the coming academic year these meetings will be held on the SECOND FRIDAY of the month, November 1958 through April 1959 at 4:00 p.m., in Room 20 at the Academy.)

FRIDAY November 14 1958	THE USE AND ABUSE OF TRANQUILIZERS *Moderator:* JOHN M. COTTON
FRIDAY December 12 1958	CURRENT THERAPY OF PULMONARY TUBERCULOSIS *Moderator:* JOHN H. MCCLEMENT
FRIDAY January 9 1959	ADVANCES IN THE MANAGEMENT OF LYMPHOMAS *Moderator:* CLAUDE E. FORKNER
FRIDAY February 13 1959	USE OF STEROIDS IN RHEUMATIC DISEASES *Moderator:* CHARLES RAGAN
FRIDAY March 13 1959	THE USE OF CHLOROTHIAZIDE AND OTHER DIURETIC AGENTS *Moderator:* JOHN H. LARAGH
FRIDAY April 10 1959	PROPHYLACTIC USE OF ANTIBIOTICS *Moderator:* PERRIN H. LONG

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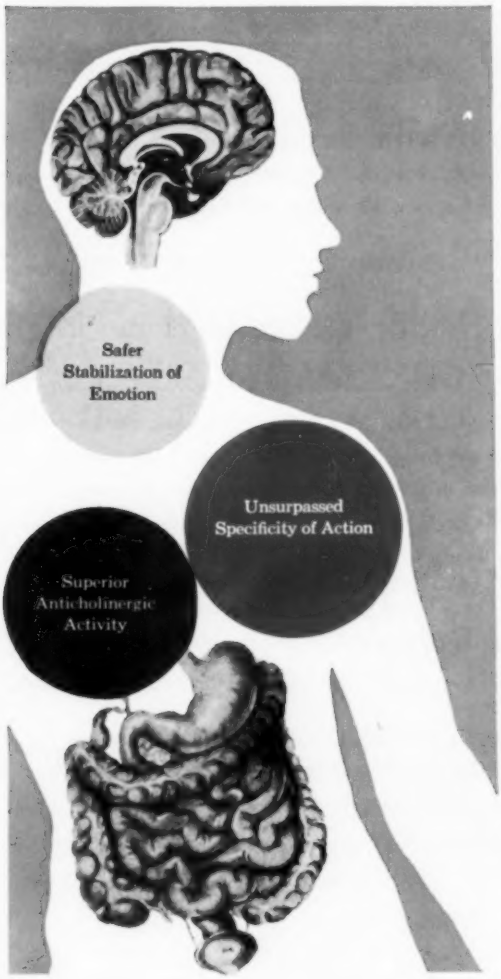

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July 3—MANAGEMENT OF PATIENTS WITH ANGINA (panel) SECTION I —Charles E. Kossmann, moderator, *Associate Professor of Medicine, New York University, College of Medicine, New York City*, with Clarence E. de la Chapelle *and* Samuel A. Thompson.

July 10—MANAGEMENT OF PATIENTS WITH ANGINA (panel) SECTION II

July 17—THYROID DISEASE (panel) SECTION I — Rulon W. Rawson, moderator, *Professor of Medicine, Cornell University, Medical College; Physician, Memorial Hospital; Chief, Division of Clinical Investigation, Sloan-Kettering Institute, New York City*, with David V. Becker, Richard S. Benua, A. Stone Freedberg, Lawrence W. Sloan, Sidney C. Werner.

July 24—THYROID DISEASE (panel) SECTION II

July 31—PRACTICAL APPLICATION OF RADIOACTIVE METALS (panel)—Lee E. Farr, moderator, *Medical Director, Brookhaven National Laboratory, Upton, Long Island, New York*, with Victor P. Bond, George C. Cotzias, Daniel Laszlo, Stuart W. Lippincott.

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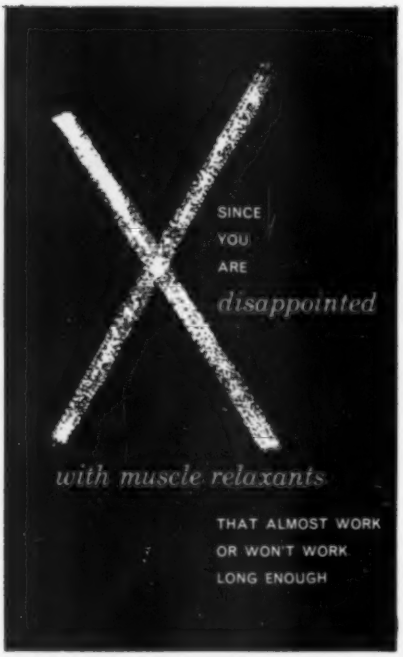

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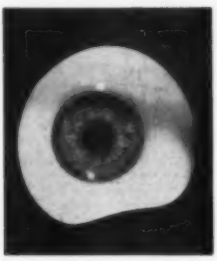

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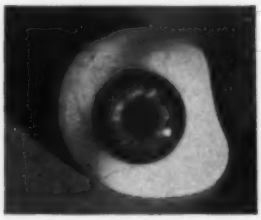

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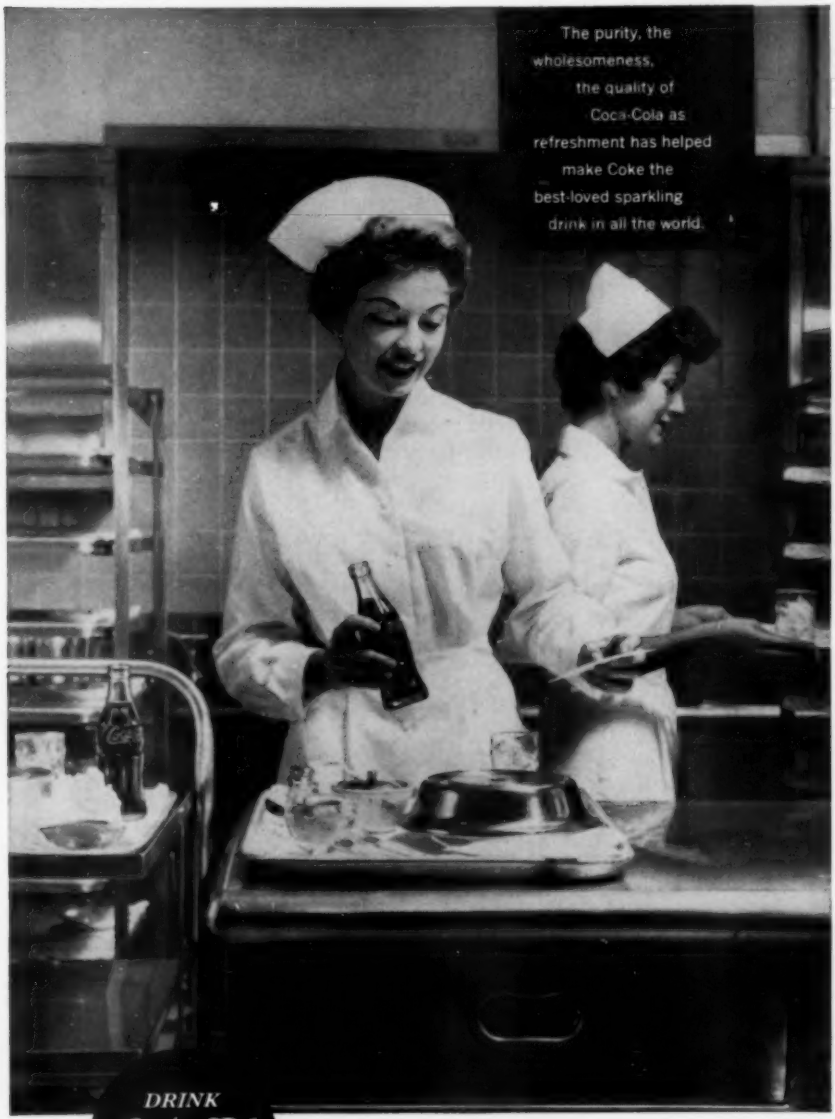
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References

1. Arlow, O., and Others: Nord. med. 46:1546 (Sept. 12) 1951.
2. Wilner, S.: Canad. M. A. J. 77:199 (Aug. 1) 1957.
3. Brister, J. M. R.: U. S. Armed Forces M. J. 4:689 (April) 1953.
4. Dinsmore, A. H.: Nord. med. 49:1234 (Sept. 22) 1953.
5. Wrenn, G. N., and Cameron, J. R.: Personal communication, Jan. 6, 1956.
6. Savage, A. N.: Personal communication, Aug. 15, 1957.

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(1) Kleckner, M. F., Jr.: J. Louisiana M. Soc. 109:188, 1956. (2) Klein, J. A.: Am. J. Gastroenterol. 28:541, 1957. (3) Kleckner, M. F., Jr.: Clin. Proc. 5:18, 1957.

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